

Report No. MMC-76/07

BREEDING DOLPHINS
PRESENT STATUS, SUGGESTIONS FOR THE FUTURE

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The views and ideas expressed in this report are those of the author(s). They are not necessarily shared by the Marine Mammal Commission or its Committee of Scientific Advisors on Marine Mammals.

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CHAIRMAN'S INTRODUCTION

The bottlenosed dolphin *Tursiops* is by far the most common cetacean captured for research or display purposes. It is also the species that presently shows the most promise for successful breeding in captivity. Marineland of Florida started keeping *Tursiops* in 1938. In the 1950's and 1960's other oceanariums started up and now there are 30 to 40 locations in the United States where these dolphins are kept.

The Marine Mammal Protection Act of 1972 emphasized the need for conservation of marine mammals. Breeding dolphins in captivity to meet the needs for these animals for research, display and public education is one means of conservation. Each dolphin reared in captivity replaces one that would be taken from the wild. In addition, a better understanding of the reproductive physiology and ethology of captive dolphins, which will be required for successful breeding, will provide basic biological information useful to the understanding of reproduction of the species in the wild.

This meeting was a workshop rather than a symposium. Therefore we have not required polished papers like those that might be submitted to a journal or published in a formal proceedings volume. This was done so that incomplete results and even anecdotal observations or untested ideas could be frankly and openly discussed. For this reason we did not record and transcribe the question and answer period for each paper, but allowed the author to do so and include this material if he desired. In most cases this turned out to be impractical because of the "free wheeling" nature of the discussion.

Some readers may wonder why papers on the cheetah and saiga were included in this discussion of dolphin breeding. We invited these papers because we felt that the comparative information might be quite valuable. Something might be learned from the highly successful attempts to breed cheetahs, although we caution that results from animals as different

from dolphins as cheetahs may not be directly applicable. The cheetah is an example of a difficult-to-breed species that has been found to have special requirements. Thus it may be used as an example in general rather than in specific terms. The saiga is of further interest because of evidence for the relationship between ungulates and odontocetes and because of some behavioral similarities.

A great deal of original information was, however, presented at this workshop. At the close of the workshop the participants decided that the material was of sufficient importance to warrant publication in a form that would make it available to everyone around the world interested in the biology and conservation of these small cetaceans. Therefore we recommended that the U.S. Marine Mammal Commission, sponsor of the workshop, take steps to make this publication possible.

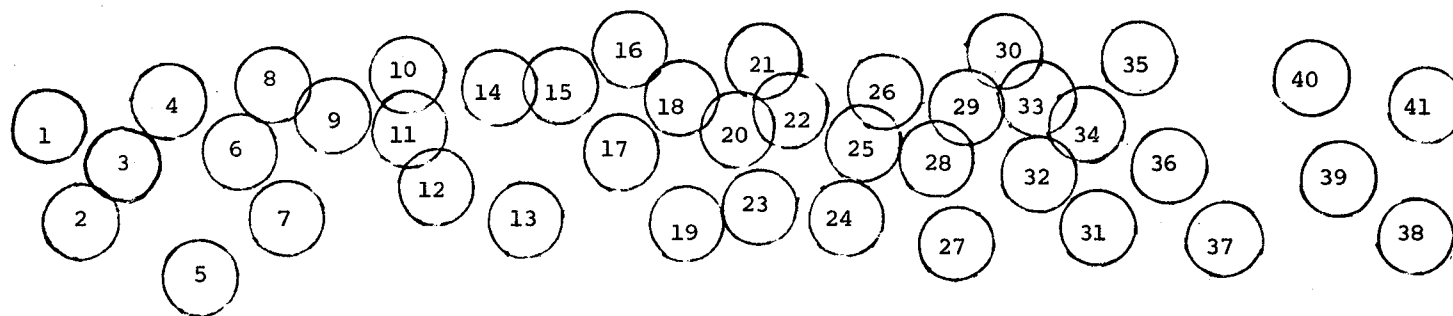
STATEMENT OF THE PURPOSE OF THE *TURSIOPS* BREEDING WORKSHOP

- A. to convene a group of knowledgeable persons to address the problem of breeding and raising *Tursiops* in captivity.
- B. the objectives are to:
 - 1. Identify the various types of problems that may affect breeding in captivity.
 - 2. Identify and summarize what has been done and what is being done to breed *Tursiops* in captivity.
 - 3. Determine what research is necessary to characterize the reproductive cycle in both males and females; and to identify behavioral, nutritional and/or environmental factors that may influence breeding, pregnancy, parturition and/or raising of young.
 - 4. Arrive at a consensus as to what needs to be done to achieve the goal of breeding *Tursiops* in captivity.
 - 5. Make recommendations to the Marine Mammal Commission so that the stated goal can be achieved with minimum delay and expense.



DOLPHIN BREEDING WORKSHOP ATTENDEES

DOLPHIN BREEDING WORKSHOP SPONSORED BY MARINE MAMMAL COMMISSION. SAN DIEGO ZOO, 8 DECEMBER 1975.



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|------------------|-----------------|------------------|----------------------|
| 1. L. Griner | 11. J. Prescott | 21. V. Gurevich | 31. J. Allen |
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| 3. K. Benirschke | 13. D. Van Heel | 23. R. Gorton | 33. M. Jones |
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| 5. M. Caldwell | 15. S. Ridgway | 25. J. Sweeney | 35. T. Gornall |
| 6. F. Wood | 16. T. Otten | 26. C. Bowers | 36. E. Shallenberger |
| 7. C. Hubbs | 17. B. Harrison | 27. I. Kang | 37. S. Leatherwood |
| 8. S. Campbell | 18. R. Herdman | 28. G. Saayman | 38. D. O'Dell |
| 9. R. Green | 19. M. Dailey | 29. C. Hui | 39. unknown |
| 10. J. Geraci | 20. R. Harrison | 30. W. Gilmartin | 40. A. Mathews |
| | | | 41. L. Cornell |

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LIST OF PLACES WHERE *TURSIOPS* ARE HELD

AUSTRALIA

1. Marineland of South Australia
P.O. Box 63
Glenelg Post Office
Glenelg, South Australia 5024

General Manager:	Mr. R.H. Porter
Curator & Trainer:	Mr. Simon Lattimer
Veterinarian:	Dr. P. Needham
<i>Tursiops</i> :	5; 2 female and 3 male between the ages of 5-9 years
Holding Facilities:	Oceanarium consisting of performing areas only with no research facilities
Source of animals:	Spencer Gulf, South Australian waters
2. Marineland of Australia
P.O. Box 823
Southport, Q 4215, Main Beach
Gold Coast, Queensland, Australia

Director:	Mr. David H. Brown
<i>Tursiops</i> :	11; 6 female and 5 male
3. Marineland
West Esplanade, Manly
New South Wales, Australia
4. Jack Evans Pet Porpoise Pool & Marine-World
P.O. Box 128
Coolangatta, Queensland, Australia 4225

Director:	Mr. Jack Evans
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4. cont.

Tursiops: 2; Lulu, 20 years in captivity
 Ringo, 6 years in captivity
 (One birth from this pair occurred on
 12/8/69, lived 12 days)

5. Pet Porpoise Pool Pty. Ltd.

Coffs Harbour

New South Wales, Australia

Managing Director: Mr. Hec Goodall

Curator: Mr. Greg Pickering

Mr. Spencer Pickering

Veterinarian (Consultants) Mr. John Heagney

Mr. Barry Moffat

Tursiops: 3; 2 female, 6 and 15 years (*catalania/aduncas*)
 1 male, 5 years (*catalania/aduncas*)

Holding Facility: Main mammal pool; 25.3 m x 12.8 m x 2.1 m deep

6. Bullen's Lion Park

Waragamba, Camden

New South Wales, Australia

Director: Mr. Andrew Wowarth-Booth

Veterinarian: Dr. R.H.J. Hyne

Tursiops: 3

7. Sea World, Surfers Paradise

P.O. Box 190

Surfers Paradise, Queensland 4217

Australia

Director: Mr. Keith Williams

Curator: Mr. Doug Cartlidge

Veterinarian: Dr. Peter Lowry (although not qualified as
 veterinarian, he has made a comprehensive
 study of dolphins)

Tursiops: 15; 5 female and 10 male

Aphy	female	20 years	Dash	male	8 years
Buttons	female	12 years	Charlie	male	12 years
Suzy	female	4 years	Lucky	male	4 years
Tuffy	female	4 years	Swirl	male	2.5 years
Sandy	female	10 years			(captive birth)
Smiley	male	12 years			
Cookie	male	10 years	Other species held in captivity		
Casper	male	20 years			
Flipper	male	7 years	<i>Sotalia</i> :		
Lobo	male	8 years	Slippery	male	10 years
Kimo	male	15 years			

7. cont.

Our facility is unusual in that all dolphins are held within sections of our 20 acre lake system which was dredged from a clean white sand area located between the Pacific Ocean and a large river estuary known as the "Broadwater". We are only two miles from the heart of Australia's largest tourist resort area.

Although we do not keep dolphins in concrete pools we do have two circular concrete tanks, one being 6.1 m diameter and the other 4.9 m diameter which can be filtered and chlorinated and these are used as hospital pools when a dolphin requires medical attention.

Successful Birth of Dolphin

On the 20th May, 1973 we were fortunate to have a successful birth of a *Tursiops* and the young dolphin which is now a little over 2.5 years of age has never suffered from any type of ailment and at the time of writing is in excellent health.

Since the young dolphin was born after the mother had been five months in captivity it is obvious that it was conceived in the wild.

All of our dolphins are captured in the shallow waters of Moreton Bay which is an extension of the previously referred to Broadwater. We use a 17.8 cm mesh soft texture net and extreme care is taken to minimize stress during the capturing operation. In almost every instance we capture family groups and where necessary hold such groups together in the one area until such time as they have become completely assimilated to captive conditions.

Holding Facilities:

Sea Arena	30.5 x 13.7 x 5.5 m	4 dolphins
"Endeavor" Lagoon	118.9 x 57.9 x 5.5 m	5 dolphins
Petting Pool	19.8 x 27.4 x 2.4 m	2 dolphins
Temporary Breeding Area	39.6 x 42.7 x 3.0 m	3 dolphins
Nursery Pool	39.6 x 27.4 x 3.0 m	2 dolphins
Hospital Pools (1)	6.1 diameter x 1.2 m	
(2)	4.9 diameter x 0.9 m	
Proposed Breeding Lake	37.2 x 118.9 x 6.1 m	

Proposed Breeding Lake: There is a lake at the extreme northern end of our project with a small sand island centrally located. We propose to develop this lake into a breeding area and we anticipate that same will be ready to accept animals by the end of April. Initially we plan to introduce the following:

- 6 female *Tursiops aduncus*
- 2 male *Tursiops aduncus*
- 4 female *Sotalia*
- 2 male *Sotalia*

Source of Animals: The Broadwater, Moreton Bay and waters of the Pacific Ocean adjacent to Surfers Paradise. Latitude 28° south.

BELGIUM

1. Dolphinarium Brügge
Boudewijn Park
Brügge, Belgium
2. Royal Zoological Society of Antwerp
Kroningin Astridplein 26
B-2000 Antwerpen, Belgium

BRASIL

1. Santos, Brasil
Tursiops: 1 or 2

CANADA

1. Montreal Aquarium
La Ronde, Isl-St. Hélène, Montréal
P.Q., Canada H3C 1A0

Director: Mr. Raymond Roth
Curator: Mr. Vincent Penfold
Veterinarian: Dr. Jean-Luc Bureau

Tursiops: 5; 4 females, 5, 8, 12, 13 years
1 male 12 years

Sources of Animals: The 5 year old female from Nassau, Bahamas
1974, all others from N.M. Stewart, Stein-
hatchee, Florida.

Holding Facility: Ovoid 24.4 x 9.1 x 4.3 m, 830,270 liters
with 5 interconnecting private chambers
1.5 m deep and 160,863 liters. Total
water 1,021,950 liters of 3% brine steri-
lized with chlorine dioxide.

Research Facility: 4 tanks 1.5 m deep, 27,252 liters. Two
labs for water chemistry, hematology,
bacteriology, pathology.

GERMANY, WEST

1. Zoo Duisburg
21 Duisburg 1
Mülheimerstrasse 273
West Germany

1. cont.

Director: Dr. Wolfgang Gewalt
Curators: Drs. Gewalt, Ostenrath, Gelmroth
Veterinarian: Drs. Horst Pauling, Leopold Plazewski

Tursiops: 4; 2 female and 2 male

Flap	male	14 years (since 1965)
Freddy	male	8 years (since 1972)
Susi	female	12 years (since 1967)
Dolly	female	8 years (since 1972)

Sources of Animals: J. Tiebor, from Florida Coast

Holding Facility: Main pool 22 x 11 x 4 m - separate room,
4 smaller pools for separation. Closed
circuit circulation using NaCl and
chlorination.

2. Westfälischer Zoologischer Garten

4400 Münster
Himmelreichalle, West Germany

Managing Director: Mr. W. Nuis
Dolphinarium operated by Harderwijk - similarly they run one at
Brügge, Belgium.

Tursiops: 3; 2 females, 1 older than 10 years
1 older than 15 years
1 male older than 10 years

Source of Animals: M. Santini, formerly at Grassey Key

Holding Facilities: Main pool, 19 x 10 x 3.7 m
2 holding pools, each 5 x 6 x 3.7 m
Artificial sea water, closed circuit.

3. Tierpark Nürnberg

85 Nürnberg
Am Tiergarten 30, West Germany

Director: Dr. Manfred Kraus
Curator: Dr. Peter Mühling
Veterinarian: Dr. Anton Gauckler

Close replica of Duisburg using chlorinated NaCl.

4. Hagenbeck Zoo

GREAT BRITAIN

1. Brighton Aquarium

Marine Parade
Brighton, Sussex, BN2 1TE, Great Britain

Director: Mr. F.C. Glover

2. Marineland Oceanarium and Aquarium
Morecambe, Lancs
Great Britain

 Director: Mr. G.D. Smith
 Manager: Mr. J.S. Ferguson
 Veterinarians: Dr. D. Taylor
 Dr. A. Greenwood (consultant)
 Dr. G. Hudson (consultant)
 Trainer: Mr. S. Gallager
 Tursiops: 4; 3 female and 1 male, 13, 11, 8, 15 years
 Holding Facilities: Two concrete pools each 274.3 sq m.
 Water capacity is 529,900 liters.
 One pool is 2.4 m deep the other 5.5 m.

3. Flamingo Park Zoo
Dirby Misperton, Malton
Yorkshire YO17 0UX, Great Britain

 Director: Mr. Don Robinson
 Curator: Mr. I.O. Gibbs

4. Royal Windsor Safari and Leisure Park
St. Leonards, Windsor
Berkshire, Great Britain

 Director: Mr. Ronald Smart
 Veterinarian: Dr. D.C. Taylor
 Tursiops: 3; 2 female and 1 male
 Holding Facilities: pools; 26.8 x 12.8 x 4.0 m - 1,135,500 liters
 3 holding pens - 3.6 x 3.6 x 1.5 m -
 51,098 liters
 7.6 x 7.6 x 4.0 m -
 191,900 liters

5. Zoological Society of London
Whipsnade Park, Dunstable LU6 2LF
Bedfordshire, Great Britain

 Curator: Dr. V.J.A. Manton
 Veterinarians: Drs. V.J.A. Manton, D.M. Jones
 Tursiops: 2 females, 1 female 5-6 years old
 1 female 12 years old
 Holding Facilities: 3 pools (one outdoor). Closed circuit gas
 chlorinated artificial water system.
 Pool 1 (outdoor) - 18.9 x 5.1 x 3.4 m
 276,305 liters
 Pool 2 (indoor) - 12.8 x 5.1 x 3.4 m
 166,540 liters
 Pool 3 (indoor including stranding shelf)
 6.1 x 4.8 x 2.4
 50,151 liters

HONG KONG

1. Ocean Park Ltd.
Wong Chuk Haug Road
Aberdeen, Hong Kong
- General Manager: Mr. Williamson
Veterinarian: Dr. Ted Hammond
- Tursiops*: 6 *Tursiops gilli*

INDONESIA

1. Jaya Ancol Oceanarium Opened 1974
Jalan Lodan Timur
Djakarta, Indonesia
- General Manager: Mr. Sukinan Handrokusumo, M.Sc.
- Tursiops*: 6; 1 female *Tursiops aduncus* (Java Sea)
100 kg, 12 years
3 male *Tursiops aduncus* (Japan)
151, 146 kg
1 male *Tursiops truncatus* (Gulf of Mexico)
170 kg
1 male *Tursiops gilli* (Hawaii) 190 kg,
8 years
1 *T. aduncus* stillbirth 1975 (conceived
in wild.
- Holding Facilities: Chlorinated recirculated salt water, pH
controlled. 22.5 x 17.5 x 5 m
10 x 3 m
7.5 x 3 m
10 x 3 m

JAPAN

1. Enoshima Marineland
17-25, Katasa Kaigan 2 Chome
Fujisawa City, Knaagawa Prefecture
Japan 251
- Curator: Mr. Kazushi Takahashi
Director: Dr. Yoshitsugu Hiroaki
Veterinarian: Mr. Asami Fujimoto
- Tursiops*: 13; 10 female and 3 male
- Holding Facility: 45 x 25 x 6 m, 6,000,000 liters

2. Ito Aquarium
4-568 Yukawa, Ito
Shizuoka Prefecture
Japan
Director: Mr. Akio Tamura
3. Nagasaki Aquarium
Shukumachi, Nagasaki
Japan
4. Mito Aquarium
Nagahama, Numazu
Shizuoka Prefecture
Japan
Director: Mr. Sisaku Hanajima
5. Shimonoseki Municipal Aquarium
Chofu-cho, Shimonoseki
Yamaguchi Prefecture
Japan
Director: Mr. Masao Nitta
6. Toba Aquarium
Toba 3-3-6, Toba City
Mie Prefecture
Japan
Director: Mr. Kusuo Nakamura
7. Kamogawa Sea World
Chiba Prefecture
Japan
Director Dr. T. Tobayama
8. Taiji Aquarium
Taiji Machi
Wakama Prefecture
Japan
9. Okinawa Oceanarium
Okinawa Prefecture
Japan
Director: Mr. Vchida
10. Shimoda Aquarium
Izu Peninsula
Schizuoka Prefecture
Japan

MALTA

1. Dolphin World Maltaaquarium, Ltd.
Dragonara Palace
St. Julian, Malta

Director: Dr. Albert Camilleri
Curator: Mr. Albert V. Everbroek

NETHERLANDS

1. Dolfinarium Strand Harderwijk
Strandboulevard
Harderwijk, Netherlands

Director: Mr. F.B. den Herder
Zoological Director: Dr. W.H. Dudok van Heel
Managing Director: Mr. J.F. Willems

Tursiops: 11; 9 female, 7 adults, 2 infants
2 male, one over 20 years, 1 over 14
Had 8 births since 1971, 3 while active
in show, all conceived in captivity.

Holding Facilities: Main pool semi-circle 30 x 15 x 4 m
Holding pools (2) 1/4 circle 11 m diameter
4 m deep
Connecting channel 40 x 3 x 1.5 m deep
4 quarantine pools 9 x 6 x 2 m
12 x 6 x 2.6 m
7 x 3.5 x 1.2 m
circular pool 6 m diam.
1 m deep
Breeding pool 21 x 8 x 2.6 m
Artificial seawater, closed circuit circulation.
2. Ouwehand Zoo Rhenen
Grebbeuweg 109, Rhenen
Prov. Utrecht, Netherlands

Directors: Mr. A. Ouwehand and Mr. J. Baars
Veterinarian: Dr. G.H.P.J. Gouda Quint
3. Dolfirama, Burg. v. Fenemapplein
Zandvoort, Netherlands

Owner: Mr. N.W. Bouwes
Veterinarian: Dr. Nederhorst

Tursiops: 6; 4 female, 3 about 10 years, 1 7 years
2 male, older than 10 and 15 years

Holding Facilities: Main pool 25 x 10 x 4 m
Holding pool 10 x 8 x 3.5 m

3. cont.

Quarantine pool 4 m diameter x 3.5 m deep
Closed circuit circulation using NaCl
solution and chlorine.

4. Dolfirodam B.V.
Scharendijke, Netherlands

Director: Mr. A.v.d. Oever
Veterinarians: Mr. C.F.G.W.v.d. Hurk (consultant)
Dr. Buck (consultant)

Tursiops: 3; 2 female 8 and 10 years
1 male 9 years

Holding Facilities: Main pool 25 x 8 x 2.8 m
Holding pool 15 x 8 x 2.8
Closed circuit circulation using NaCl
solution and chlorine.

NEW ZEALAND

1. Hawke's Bay Aquarium
P.O. Box 167
Napier, New Zealand

Director: Mr. L.P. Ryan
Curator: Mr. G.L. Dine

2. Marineland of New Zealand Opened 1974
Private Bag
Napier, New Zealand

Manager: Mr. Pat McIlroy
Tursiops: None at present. Has 6 *Delphinus delphis*.
Previously kept *Tursiops truncatus*
Lagenorhynchus obscurus
Cephalorhynchus hectori
Kogia breviceps

3. Mount Maunganui Marineland Ltd. Opened 1966
Tauranga
New Zealand

Owner: Mr. P.R. Sorrenson
Tursiops: None at present.
Previously kept *Delphinus delphis*
20' beaked whale with foetus

4. Marineland
Orewa, New Zealand

Manager Mr. Horokin

4. cont.

Tursiops: At present aquarium is closed.
Previously kept *Delphinus delphis*

5. Pacific Sea Aquarium Opened 1970
Picton, New Zealand

Manager: Mr. Ross Hedge

Tursiops: At present aquarium is closed.
Previously kept *Delphinus delphis*
Lagenorhynchus obscurus

SOUTH AFRICA

1. Dolphinarium and Oceanographic Research Inst. Opened 1976
P.O. Box 736, 2 West Street, Durban
Natal, South Africa

Owner: South African Association for Marine
Biological Research

Institute Director: Dr. A. Heydorn

Asst. Director

Dolphinarium: Mr. E.A. Fearnhead, B.Sc.

Tursiops: 2; 1 female and 1 male
1 *Lagenorhynchus obscurus*

2. Port Elizabeth Oceanarium
Museum, Beach Road
Humewood, Port Elizabeth
South Africa

Director: Dr. John Wallis

Marine Biologist: Mr. G.J.B. Ross, M.Sc.

Tursiops: 5; 2 female, 1 juvenile conceived and born
in captivity and 1 adult
3 male, 1 juvenile conceived and born
in captivity and 2 adults

Holding Facilities: One large dolphin pool incorporating two
small isolation tanks - 61 x 55 x 4.6 m
deep at deepest point, 4,742,400 liters.

Source of Animals: 3 adults netted off King's Beach, Humewood,
opposite facility.

SPAIN

1. Marineland S.A.
Costa D'en Blanes
Palma Nova
Mallorca, Spain

1. cont.

Director: Mr. David Mudge
Curator: Mr. Helmut Berchtold
Veterinarians: Drs. D.C. Taylor and A. Greenwood
Tursiops: 4; 2 female and 2 male, ages 13-15 years
Holding Facilities: Main show pool - 30 x 12 x 3 m deep
Two holding pools - 14 x 7 x 2.5 m deep

2. Parque Zoologico De Barcelona
Parque de la Ciudadela
Barcelona 5, Spain

Director: Dr. A. Honch
Manager: Mr. B. González

SWEDEN

1. Kolmardens Djurpark
Kolmarden, Norrköping
Sweden

Director: Mr. Ulf Svensson
Veterinarian: Dr. Bengt Ole Röken
Tursiops: 5; 2 female, 7 and 20 years
3 male, 8, 15 and 25 years
Holding Facilities: Main pool - irregular 800 sq. meters by
4 m deep
Holding pool - 200 sq. meters by 4 m deep
Closed circuit circulation using NaCl and
chlorination.

SWITZERLAND

1. Knie Kinderzoo
8640 Rapperswill
Switzerland

Owner: Mr. Gebr. Knie
Tursiops: Had *Tursiops* conceive in captivity and
give birth to live infant 7/29/75.
Holding Facility: Irregular shape pool - 10 x 15 x 3.5 m deep
using NaCl and chlorination.

UNION OF THE SOVIET SOCIALIST REPUBLICS

All *Tursiops* were taken from the Black Sea. (Submitted by V.S. Gurevich)

1. Karadag Biological Station. Institute of Biology of the South Seas,
Academy of Science of the Ukrainian SSR. Situated in the vicinity
of the city Feodosiya (Black Sea). The manager is Dr. A.A. Titov.

1. cont.

This station works year round and very closely with the Acoustics Institute of the Academy of Science of USSR, Moscow, particularly with Dr. N.A. Dubrovsky. They have one permanent tank, where 10 specimens of *Tursiops truncatus* (4 males and 6 females) are kept during winter. As far as is known they have never had success in breeding dolphins.

2. Kazachya Bay Station which is situated in the vicinity of city Sevastopol' (Crimea) in the Black Sea is the principal coordinator in any research on marine mammals. The head is V.V. Belyaev. They work very closely with institutions which have an interest in hydrobionics investigations. Protasov is a medical (human) doctor, who acts as medical officer (veterinarian) and takes care of the health of all the experimental animals. This station has worked year round since 1967, having not only sea pens, but a few permanent warm water tanks. The number of bottlenosed dolphins maintained varies from year to year, but averages from 10 to 18 animals. They have never bred *Tursiops* in captivity, although several births have occurred. All calves have died.
3. Former station of the TSNII AG, situated in the vicinity of the city of Gagra (Black Sea), Pitsunda. Although this station has very good facilities for keeping animals in captivity, they have slowed down any experimental work with marine mammals. For the last three years a few *Tursiops truncatus* and common dolphins have been maintained at this place. No special breeding program has been active either in the past or the present. The few births which have occurred in the past have always resulted in stillborn or death shortly after birth.
4. Station Bol'shoy Utrish in the vicinity of the cities Anapa and Novorossiysk (Black Sea). There is a summer field biological station of the Institute of the Evolutionary Ecology and Animal Morphology of the Academy of Sciences of the USSR (Director Academician V.E. Sokolov). Head of this station is Dr. E.V. Romanenko, whose main interest is research on echolocation, sound production and behavior. This station is functional only during summer from April till November. They maintain a maximum of 10-15 *Tursiops*. Some of them are brought from Kazachya Bay, because they live there during the winter. There is no formal animal husbandry program at this facility.
5. Oceanarium at Batumi (opened for the public in 1975) was built on the site of the VNIRO Fishery Station. The head of the research program with marine mammals is Dr. A.P. Shevalev who works very closely with the people from Kazachya Bay. The number of *Tursiops* at this oceanarium at the present is unknown, but thought to be 7 or 8. Two births were announced for mid-November and early December 1975. These subsequently died, however.

UNITED STATES

California

1. Marineland of the Pacific, Inc.

P.O. Box 937

Palos Verdes, California 92704, USA

President: Mr. Michael Downs

Curator: Mr. Tom Otten

Associate Curator: Mr. Brad Andrews

Veterinarian: Dr. D.D. Edwards

Tursiops: 4 *Tursiops gilli*
14 *Tursiops truncatus*, 7 female and 7 male,
females aged 7, 7, 7, 9, 13, 13 and 18
years and males aged 4, 7, 10, 13, 15,
18 and 20 years.

Holding Facilities: Nine *T. truncatus* are housed in a show
tank that consists of holding pens off the
main tank with a capacity of 1,892,500
liters. The other five *T. truncatus* are
housed in a community pool with the four
T. gilli. This tank is egg-shaped with
a capacity of 567,750 liters.

2. Marineworld/Africa USA

Marineworld Parkway

Redwood City, California 94065, USA

Manager: Mr. Michael B. Demetrios

Curator: Mr. Stan Searles

3. Seaworld, Inc.

1720 South Shores Road

San Diego, California 92109, USA

Director: Mr. Frank Powell

Curator: Dr. Lanny Cornell

Tursiops: 6 *Tursiops gilli*, 3 female and 3 male
28 *Tursiops truncatus*, 14 female and 14 male

Holding Facilities: Breeding/Research Pool, Shamu Stadium
18.3 diameter by 4 m deep, 846,250 liters
Beluga Whale Pool - main pool
4.6 x 12.2 x 3.6 m deep, 200,132 liters
Beluga Whale Holding Facility
4.9 diameter by 1.6 m deep, 30,412 liters
Connecting channel between main pool and
holding facility, 1.8 x 1.8 x 1.7 m,
5,621 liters
Holding Tanks 1, 2, and 3 (rear holding area)
10.7 diameter by 2.4 m deep, 170,325 liters

3. cont.

Medication Tanks 1 and 2 (rear holding area-
interlock between holding tanks 1, 2, and
3 to form a continuous 5-pool facility)
5.7 diameter by 1.5 m deep, 27,252 liters
Holding Tanks 4 and 5 (rear holding area)
5.0 diameter by 1.5 m deep, 26,026 liters
Lagoon
irregular shape, maximum width 85.3 m,
maximum length 100.6 m, depth range 1.8-
4.3 m, capacity 7,570,000 liters
Dolphin Feeder Pool - interlocking 3-pool
system - outer pools, 6.1 diameter by 2.3
m deep, 59,633 liters; center pool 4.6
diameter by 1.5 m deep, 25,000 liters;
total system 158,345 liters

4. Naval Ocean Systems Center (formerly Naval Undersea Center)
San Diego, California 92152, USA

Director: Mr. B.A. Powell
Veterinarian: Dr. S.H. Ridgway

Tursiops: 23 *Tursiops truncatus*, 12 female and 11 male
1 *Tursiops gilli*, male

	<u>Acquired</u>	<u>Source</u>	<u>Sex</u>	<u>Name</u>	<u>Est. Age</u>
(Tt)	1962	W-Miss	Male	Maui	19
	1966	W-Fla	Female	Wave	30
			(spayed)		
	1966	W-Fla	Female	Cyclops	17
	1967	W-Fla	Male	Snooper	11
	1967	W-Fla	Male	Snorkel	10
	1968	W-Fla	Female	Slan	11
	1968	W-Fla	Female	Toad	17
	1970	W-Fla	Male	Nemo	10
	1971	W-Miss	Male	Otto	9
	1972	W-Fla	Male	Red #2	10
	1972	W-Fla	Female	Brown	12
	1972	W-Miss	Female	Blue	10
	1972	W-Fla	Male	Little Bit	6
	1972	W-Miss	Male	Whiskey	10
	1972	W-Miss	Female	Laura	16
	1972	W-Miss	Female	Pandora	12
	1974	W-Miss	Male	Julio	7
	1974	W-Miss	Male	Arrow	8
	1974	W-Miss	Female	Deebee	10
	1974	W-Miss	Male	Chauncy	8
	1974	W-Miss	Female	Jenny	9
	1974	W-Miss	Female	Connie	8
	1974	W-Miss	Male	Orange	6
(Tg)	1971	Japanese	Male	Ivan	7
		Deer Park			
		California			

4. cont.

W - indicates caught from wild

Miss - indicates caught in the waters of the state of Mississippi

Fla - indicates caught in the waters of the state of Florida

Connecticut

5. Mystic Marinelife Aquarium

Mystic, Connecticut 06355, USA

Director: Mr. Stephen Spotte

Animal Behaviorist: Dr. William A. Myers

Veterinarian: Dr. J. Lawrence Dunn

Tursiops: 4; 2 females aged 5 years and 2 males aged 4 and 5 years

Holding Facilities: Main pool - poured concrete, 21.3 x 12.2 x 6.1 m deep; underwater viewing satellite pools attached to main pool, 9.1 m diameter by 3.7 m deep. Closed system recirculated through rapid sand filters approximately once per hour. Low level chlorination is employed.

Source of Animals: All four animals were captured on the Atlantic coast of Florida in November 1972. They were flown to Mystic in August 1973.

Florida

6. Aquatarium & Zoological Gardens

6500 Beach Plaza Road

St. Petersburg Beach, Florida 33706, USA

Curator: Mr. Richard A. Whitman

General Manager: Mr. Michael D. Haslett

Director of Training: Mr. Thomas E. Haslett

Veterinarian: Dr. G.T. Goldston

Tursiops: 14; 6 females, 3 females aged 14-20 years, 2 aged 6-10 and 1 aged 3-6 years, 8 males, 5 aged 12-14 years, 2 aged 5-10 and 1 aged 3-5 years

There have been 2 births; 1 conceived in captivity, lived to 2 years and 1 still-birth conceived in wild.

Holding Facilities: Main tank - 30.5 m diameter by 7.6 m deep
Dome tank - 18.2 m diameter by 3.7 m deep
No. 1 training tank - 9.1 x 15.2 x 2.1 m deep
Round training tank - 4.6 x 2.4 m deep

Source of Animals: We catch and maintain all of our *Tursiops*. Our range is from Sarasota to New Port Richey.

7. Miami Seaquarium
4400 Rickenbacker Causeway
Virginia Key
Miami, Florida 33149, USA

Manager and Curator: Mr. Warren Zeiller
Veterinarian: Dr. Jessie R. White

Tursiops: 23; 17 females and 6 males

Holding Facilities: 3 pools - 12.2 m diameter by 1.8 m deep
1 pool - 12.2 m diameter by 3.7 m deep
Open system tanks.

Source of Animals: Yacht Seaquarium
8. Marineland of Florida
Route 1 Box 122
St. Augustine, Florida 32084, USA

General Manager: Mr. Clifton Townsend
Curator: Mr. Robert Jenkins
Veterinarian: Dr. Ronald F. Jackson

Holding Facilities: Pool - 22.9 m diameter by 3.7 m deep
Open ocean circulation.
9. Sea World of Florida
7007 Sea World Drive
Orlando, Florida 32809, USA

Director: Mr. George Becker
Curator: Mr. Edward D. Asper
Veterinarian: Dr. Dedrick Beusse

Tursiops: 2 Pacific bottlenosed dolphins, 1 female
and 1 male
8 Atlantic bottlenosed dolphins, 5 female
and 3 male
10. Aquatic Mammals Enterprises
Key Largo, Florida 33037, USA

Directors: Charles and Leigh Riggs
Veterinarians: Drs. George Baker and Robert Foley

Tursiops: 4; 1 female and 3 male
11. Ocean World
1701 S.E. 17th Street
Fort Lauderdale, Florida 33316, USA

Director: Mr. Charles Beckwith, Jr.
Veterinarian: Dr. Will R. Latimer

Tursiops: 9

11. cont.

Holding Facility: 1 circular tank - 11.2 x 4.9 m deep,
832,700 liters

12. Gulf World

West Panama City Beach, Florida, USA

Owner: Mr. Wesley Burham

Curator: Mr. Carl Selph

Tursiops: 3

13. Waltzing Waters Aquarama

P.O. Box 68

Cape Coral, Florida 33304, USA

Director: Mr. Jack Scarpuzzi

Tursiops: 2

14. Flipper Sea School

P.O. Box Dolphin

Marathon Shores, Florida 33052, USA

Director: Mr. Jim Lewis

Veterinarian: Dr. Jesse M. White

Tursiops: 20; 4 births since 8/1/73, 2 female and
2 male of which 2 are still living.
Natural water environment.

15. Theatre of the Sea

Matacumbe Key, Florida

Director: Mr. P. McKinney

Tursiops: 2

16. Gulfarium

Fort Walton Beach, Florida 32548, USA

Director: Mr. John B. Siebenaler

Veterinarians: Drs. Phil Blumer and John Augsburg

Tursiops: 7; 6 female and 1 male

Herman	male	11 years
Windy	female	13 years
Belinda	female	15 years
Peebles	female	10 years
Kim	female	11 years
Jeanine	female	12 years
Joyce	female	unknown

Holding Facilities: Performing tank - 1,892,500 liters
Training tanks - 113,550 and 132,475 liters
Holding tank - 151,400 liters
Training or sick bay tank - 170,325 liters

The following individuals are keeping *Tursiops*.

Number of *Tursiops*

17. Mr. Gene Asbury
Sugar Loaf Motel
Sugar Loaf Key, Florida 33044, USA 1
18. Mrs. Betty Brothers
Brothers Motel
Little Torch Key, Florida 33043, USA 2
19. Mr. John Slater
3054 Gordon Drive
Naples, Florida 33940, USA 3
20. Mr. Harvey Hamilton
Villa Marada, Florida 2

Hawaii

21. Naval Ocean Systems Center (formerly Naval Undersea Center)
Box 997
Kailua, Oahu, Hawaii 96734, USA
Division Head: Mr. Richard Soulé
Veterinarian: Dr. Gary Colgrove
Tursiops: 18 *Tursiops truncatus*, 9 female and 9 male
1 *Tursiops gilli* male

	<u>Acquired</u>	<u>Source</u>	<u>Sex</u>	<u>Name</u>	<u>Est. Age</u>
(Tt)	1967	W-Fla	Male	Svenny	11
	1969	W-Fla	Male	E. Kahi	12
	1969	W-Fla	Female	E. Lua	12
	1969	W-Fla	Male	E. Hiku	12
	1969	W-Fla	Female	Kae	12
	1969	W-Fla	Female	Joe	11
	1970	W-Fla	Male	Hepatuna	11
	1970	W-Fla	Female	Sheba	8
	1971	Sea World California	Female	Sandy	20+
	1972	W-Fla	Male	Anakoa	9
	1972	W-Miss	Female	Goose	7
	1972	W-Miss	Female	Ginger	10
	1972	W-Miss	Male	Ralph	7
	1972	W-Miss	Female	Bertha	14
	1972	W-Miss	Female	Shelly	10
	1974	W-Miss	Male	Jake	10+
	1974	W-Miss	Male	Mauka	6
(Tg)	1975	Sea Life Park, Hawaii	Male	Papale	10+

21. cont.

W - indicates caught from wild

Miss - indicates caught in the waters of the state of Mississippi

Fla - indicates caught in the waters of the state of Florida

22. Sea Life Park

Waimanalo, Hawaii 96795, USA

Director: Dr. Edward Shallenberger

Curator: Ms. Ingrid Kang

Veterinarian: Dr. David MacKay

Tursiops: 8 Atlantic bottlenosed, 5 female and 3 male
3 Pacific bottlenosed, 2 female and 1 male

Illinois

23. Chicago Zoological Society

Brookfield Zoo

Brookfield, Illinois 60513, USA

Director and Curator: Dr. George B. Rabb

Lead Keepers: Mr. H. Buttron and Mr. E. Krajniak

Veterinarian: Dr. D. Laughlin

Tursiops: 3; 2 females and 1 male, aged 2, 12 and 20+

Holding Facility: Pool - 30.5 x 7.6 x 2.1-5.5 m deep,
757,000 liters artificial water

Source of Animals: Florida Keys and east coast of Florida

Massachusetts

24. New England Aquarium

Central Wharf

Boston, Massachusetts 02110

Director: Mr. John Prescott

Curator: Mr. Lewis Garibaldi

Tursiops: 6; 4 females and 2 males

25. Atlantic Aquarium

1 State Park Road

Hull, Massachusetts 02045

Director: Mr. Gilmore

Tursiops: 2; 1 female and 1 male

Mississippi

26. Marine Life Inc.

c/o Marine Animal Productions

150 Debuys Road

Biloxi, Mississippi 39531, USA

26. cont.

Owner: Mr. Don Jacobs
Manager: Mr. Robert Corbin
Veterinarian: Dr. Gerald Dukes
Tursiops: 22; 13 at Marine Life Inc., Mississippi
9 at Seven Seas, Texas
Holding Facilities: Main pool - 24.4 m diameter by 2.9 m deep,
2,323,233 liters
Stadium pool - 30.5 x 9.1 x 3.0 m, 757,000
liters
Bay pool - 36.6 x 16.8 x 3.0 m, 1,514,000
liters

Missouri

27. Six Flags over Mid-America
St. Louis, Missouri, USA

Manager: Mr. Larry Cochran
Curator: Mr. Marvin Boatman
Tursiops: 4; 2 females and 2 males

North Carolina

28. Quinlan Marine Attractions
Route 1
Lincolnton, North Carolina 28092, USA

Director: Mr. Ralph Quinlan
Veterinarian: Dr. Wayne Jones
Tursiops: 27

New York

29. New York Aquarium - New York Zoological Society
Boardwalk at West 8th Street
Seaside Park
Brooklyn, New York 11224, USA

Director: Dr. James A. Oliver
Curator: Dr. William Flynn
Tursiops: 1 female

30. Niagara Falls Aquarium
701 Whirlpool Street
Niagara Falls, New York 14301, USA

Director: Mr. Leonard F. Bryniarski
Veterinarians: Drs. J.L. Dunn and S. Al-Nakeeb

30. cont.

Tursiops: 4; 3 female and 1 male

<u>Name</u>	<u>Sex</u>	<u>Weight</u>	<u>When, Where Acquired</u>
Sailor	male	153 kg	1966 Dead Man's Bay, Florida
Misty	female	145 kg	1966 Key Largo, Florida
Gabriella	female	182 kg	1974 Creative Animal Techniques, Cape Cod, Massachusetts
Turnip	female	107 kg	Born to Gabriella 7/25/74 in Cape Cod

Holding Facilities: Concrete pool (above, below viewing)
Main pool - 12.2 m diameter by 2.7 m deep
Tunnel to back up pool - 4.6 x 3.0 x 1.2 m
Closed system, earth filter q 40 m. Tap
water, chlorinated, brine added to specific
gravity 1.018 at 25°C.

Puerto Rico

31. Ocean Life Park Aquarium
Boca de Congrejos Isla
Villamar, Isla Verde,
San Juan, Puerto Rico 00913, USA

Director: Mr. Robert E. Pile
Curator: Mr. Regino Cruz
Veterinarian: Dr. Jessie White

Tursiops: 1 six year old female

Holding Facilities: Pool - 15.6 x 3.3 m
Holding pool - 1.2 x 1.8 m

Texas

32. Sea-Arama Marineworld Inc.
91st Street and Sea Wall Boulevard
Galveston, Texas 77550, USA

Manager: Mr. Dale Ware
Curator: Mr. Ken Biggs

Tursiops: 10; 9 females and 1 male
1 stillbirth (twins)

33. J & L Attractions, Inc. d/b/a/ Seven Seas
P.O. Box 777
Arlington, Texas 76010, USA

President: Mr. Jacobs
Manager: Mr. Corbin

Tursiops: 9; 4 females and 5 males

33. cont.

Holding Facilities: Show pool - 23.9 x 10.7 x 4.9 m deep,
984,100 liters with
Two holding pools - 8.8 m diameter by 2.7
m deep
Two training pools- 8.8 m diameter by 3.7
m deep, 484,480 liters

Washington

34. Seaworld

Pier 56

Seattle, Washington 90101, USA

Director: Mr. Don Goldsbury

Veterinarian: Dr. Tag Gornall

Tursiops: 2; Two dolphins from the San Diego Sea
World were there temporarily during
this period.

DOLPHIN BREEDING WORKSHOP AGENDA

SESSION I - December 8, 1975

History and Current Status of Dolphin Reproduction in Captivity - F.G. Wood, Chairman		Paper	Page
		#	#
0800-1810	Opening remarks and introduction of program. S.H. Ridgway, Naval Ocean Systems Center, San Diego, California, USA.		
0810-1835	Births of dolphins at Marineland of Florida, 1939- 1969, and comments on problems involved in captive breeding of small cetacea. F.G. Wood, Naval Ocean Systems Center, San Diego, California, USA.	1	47
0840-0855	Miami Seaquarium dolphin breeding program. Warren Zeiller, Miami Seaquarium, Miami, Florida, USA.	2	61
0905-0920	Experience of Sea World in breeding dolphins and plans for the future. Lanny Cornell, Sea World, San Diego, California, USA.	3	66
0930-0945	Experience of Marineland of the Pacific and New England Aquaria in dolphin reproduction. John Pres- cott, New England Aquarium, Boston, Massachusetts, USA.	4	71
0950-1005	Coffee Break		
1005-1020	Dolphin births at Sea Life Park. E. Shallenberger, Sea Life Park, Waimanalo, Hawaii, USA.	5	77

		Paper #	Page #
1030-1045	Dolphin reproduction in oceanaria in Australasia. J.F. Allen, Jaya Ancol Oceanarium, Djakarta, Indonesia.	6	85
1055-1110	Dolphin reproduction in western Europe. W.H. Dudok van Heel, dolfinarium Harderwijk, Holland.	7	109
1120-1135	Observations on the sexual behavior of Indian Ocean bottlenosed dolphins (<i>Tursiops aduncas</i>). G.S. Saayman, Snake Park and Oceanarium, South Africa.	8	113
1145-1200	A survey of dolphins in Japanese aquariums. Marvin Jones, San Diego Zoo, San Diego, California, USA.	9	130
1215-1400	Lunch		
<u>SESSION II</u>			
Behavioral and Ethological Considerations - W.E. Evans, Chairman			
1400-1420	Social interactions and reproduction in the Atlantic bottlenosed dolphin. Melba C. and David K. Caldwell, St. Augustine, Florida, USA.	10	133
1435-1450	Mother-infant interactions of bottlenosed dolphins in captivity and at sea. J. Stephen Leatherwood, Naval Ocean Systems Center, San Diego, California, USA	11	143
1455-1510	Observations on dolphin young. W.E. Evans, Naval Ocean Systems Center, San Diego, California, USA. (Evans was unable to attend)	--	--
1515-1530	Observations of a dolphin calf at Sea World. V.S. Gurevich, Sea World, San Diego, California, USA.	12	168
1530-1545	Coffee Break		
<u>SESSION III</u>			
Anatomy of the Reproductive Organs - R.J. Harrison, Chairman			
1545-1605	Gross Anatomy of the reproductive organs. R.F. Green, Ventura College, Ventura, California, USA.	13	185
1615-1645	Ovarian appearances and histology in <i>Tursiops truncatus</i> . R.J. Harrison, University of Cambridge, Cambridge, England.	14	195
1700-1930	Dinner		
1930-2200	Round Table Discussion		

SESSION IV - December 9, 1975

Reproductive Physiology - S.H. Ridgway, Chairman

	<u>Paper #</u>	<u>Page #</u>
0800-0815 Collection and storage of semen from dolphins. Harold Hill and W.G. Gilmartin, San Diego Zoo and Naval Ocean Systems Center, San Diego, California, USA.	15	205
0820-0835 Diagnosis of pregnancy with Doppler sonography and other techniques. J.C. Sweeney, Naval Ocean Sys- tems Center, San Diego, California, USA.	16	211
0840-0900 Role of diagnostic ultrasound in evaluating pregnan- cies in <i>Tursiops truncatus</i> . George R. Leopold, Uni- versity of California at San Diego, San Diego, Cali- fornia, USA.	17	217
0905-0920 Nutritional considerations in dolphin reproduction. J.R. Geraci, University of Guelph, Guelph, Ontario. Canada.	18	220
0930-0945 Growth and physical indices of maturity. Clifford Hui, Naval Ocean Systems Center, San Diego, Cali- fornia, USA.	19	231
0950-1010 Coffee Break		
1010-1025 Steroid hormone studies in pregnant and non-pregnant dolphins. Melvyn Richkind, University of California at Los Angeles, Los Angeles, California, USA.	20	261
1035-1110 Hormone studies in male dolphins. Howard Judd and S.H. Ridgway, University of California at San Diego and Naval Ocean Systems Center, San Diego, California, USA.	21	269
1110-1135 Difficult births and neonatal health problems in small cetacea. J.C. Sweeney, Naval Ocean Systems Center, San Diego, California, USA.	22	278
1145-1200 Parallel breeding problems in captive land mammals. J. Dolan, San Diego Zoo, San Diego, California, USA.	23	288
1205-1400 Lunch		

SESSION V

1400-1425 Breeding of cheetahs at the San Diego Zoo. R. Herdman, San Diego Zoo, San Diego, California, USA.	24	294
1425-1500 Genetics of endangered species as applied to the breeding of dolphins. M. Soule, University of California at San Diego, San Diego, California, USA.	25	303

1500-1515 Coffee Break
 1515-1615 Round Table Discussion
 1620-1645 Wrap-up and recommendations for the future. Kurt Benirschke, San Diego Zoo, San Diego, California, USA.
 1650- Adjournment

PAST BREEDING RECORD

There have been about 150 births of bottlenosed dolphins in captivity. We have identified 151 and suspect that there have been a few others that have escaped notice. The most successful breeding colony yet established has been at Marineland of Florida in St. Augustine. The Miami Seaquarium, Sea Life Park, Hawaii, Sea World of San Diego, Marineland of the Pacific, and the Dolphinarium, Harderwijk, Netherlands, currently have active breeding programs.

<u>INSTITUTION OR COUNTRY</u>	<u>NO. OF BIRTHS</u>
Australia	4
Ocean Park, Ltd., Hong Kong	1
Jaya Ancol Oceanarium, Indonesia	1
Japan	22
Dolphinarium, Netherlands	8
Port Elizabeth Oceanarium, South Africa	2
Barcelona, Spain	2
Marineland S.A., Spain	1
Knie Kinder Zoo, Switzerland	1
Batumi, Soviet Union	2
Marineland, California	8
Naval Ocean Systems Center, California	4
Sea World San Diego, California	7
Mystic Marinelife Aquarium, Connecticut	1
Aquatarium, Florida	2
Flipper Sea School, Florida	4
Gulfarium, Florida	3
Marineland of Florida, Florida	40

<u>INSTITUTION</u>	<u>NO. OF BIRTHS</u>
Miami Seaquarium, Florida	23
Ocean World, Florida	4
Sea Life Park, Hawaii	9
Sea Arama, Texas	2
	<hr/>
TOTAL	151

Of the dolphins born in captivity at least one-third were conceived in the wild. A large percentage (80% or so) of all animals conceived in captivity have been bred in an oceanarium-show situation similar to that at Marineland of Florida. This type of porpoise show has been copied many times and at many locations. In these situations there are usually three to as many as a dozen porpoises. Shows are put on several times daily and usually involve animals making jumps, retrieving balls and the like. The main performers are usually one or two large cows.

Show animals in training have been successful breeders and there is no evidence that having the animal trained and in a show is a deterrent to breeding unless it keeps the animal continuously away from a possible partner.

Interruption of breeding was identified when there was absence of a successful sire. For example Ocean World at Fort Lauderdale, Florida, captured 4 females and 1 male from a single herd. The group produced 4 calves between 1968 and 1972 when the bull was shipped to Malta. There have been no calves since. The general opinion was that a good mature bull was the most important factor in a successful breeding colony.

Mr. Warren Zeiller of the Miami Seaquarium showed a film of the births in the main tank at Seaquarium. There were five births in the fall of 1975. It was obvious from the film that there was a great deal of excitement in the tank while the births were in progress. This led to a discussion about the pros and cons of having other animals in the tank with a female about to calve. Excitement and adrenalin release can block oxytocin, the hormone necessary for milk let-down which can interfere with nursing. There were periods of aggression, and other females often "stole" calves from the mother for long periods of time. Some thought that it would be better to have the female alone for calving.

Others thought that it is better to have other animals present. For example, there is a great deal of anecdotal information about another female, an "Auntie", assisting the mother. The Miami Seaquarium plans to continue the present herd breeding situation. It is hoped that different strategies will be adopted by other institutions so that a comparison can be made of different methods.

QUESTIONS AND ANSWERS

1. What is the youngest and oldest age at which a female *Tursiops* has calved?
 - A. 7 years, Marineland of Florida, Florida.
 - B. 26 years, Naval Ocean Systems Center, California.
2. Have twins ever been produced in captivity?
 - A. Yes, at Sea Arama, Texas, 1974, stillbirths.
3. Has cross-breeding ever occurred among dolphins?
 - A. Yes, at Sea Life Park, Hawaii, a *Steno bredanensis* and Atlantic *tursiops* calf was produced. Also it is learned that Atlantic and Pacific bottlenosed dolphins have produced a calf at Marineland of the Pacific, California.
4. What is the smallest tank in which *Tursiops* have successfully reproduced?
 - A. 6 m diameter and 1.6 m deep at Marineland of Florida.
5. What is the largest number of calves that have been produced in one dolphin tank community in one season?
 - A. 5, Miami Seaquarium, Florida, fall 1975.
6. What are some characteristics of a sexually mature bull *Tursiops*?
 - A. Age estimate 13 years, or older but definitely over 7.
 - B. Length/weight (and ratio) 2.45 to 3.0 meters length by 150 to 300 kg.
 - C. Large keel and extra girth at base of tail stock.
 - D. Head appears smaller in relation to body than nonmature males and females. Extra girth in the shoulder region.
 - E. Testosterone level over 1,000 ng per 100 ml of serum during reproductive season.
 - F. Often highly scarred.
7. What is the shortest period of time between successive calvings by a *Tursiops* female?
 - A. 13 months, Flipper Sea School, Florida, 1st stillborn. The most frequent interval of live births - 2 years, Marineland of Florida.

PROBLEMS DELINEATED AND SOME SUGGESTED SOLUTIONS

Various problem areas were delineated during the formal sessions and in the evening discussions. They will now be considered individually.

A. Construction of pool, size and shape of pool, water conditions.

Various pool sizes and shapes have been used successfully, and no complete accord was reached as to what is optimal. Also, while some considered the need for separation of a pregnant female, pregnant porpoises participated in shows in Holland, and the muscular activity was even considered to be advantageous. Dr. Saayman suggested that a circular tank is not ideal because of difficulties in acoustic orientation. Since their construction of irregularly shaped tanks they have had less aggression, fewer gastrointestinal problems and rarely now are plastic items ingested. Marvin Jones reported that in Enoshima (Japan) rectangular pools are used successfully, and divisions are created with heavy nets or chains hanging into the water. This allows ready separation of animals and change in pool size.

The pools should probably be at least 10-15 m in size; surface area is more important than depth. The optimal pool size and shape are not yet delineated and require future study. There should be attached isolation facilities for purposes of treatment and in event of aggressive behavior. A system of channels has worked well in Holland. More data are required on pool size, water temperature, isolation, water additives (NaCl and possibly other minerals) and their relation to successful breeding.

B. Growth of *Tursiops*.

At present the age at puberty is estimated to be from 10-12 years but exact data are lacking. Some observers suggested that bulls may be mature already at 7 years. Mature males measure about 245 cm and weigh 180-230 kg. Precise comparative data of *Tursiops* subspecies are lacking. It is desirable to define the characteristics of a sexually mature male, for the availability of a single capable bull is an overriding requirement for breeding. A very successful bull at Marineland, Florida, measured

264 cm. When released it was difficult to obtain an adequate replacement. The same institution has a captive-born female 24 years old. Gestation has been about 12 months, and 18 months of nursing has been observed. The young can be weaned between 12 and 18 months, and when over 180 cm they can probably get along on solid food.

Usually mammalian growth patterns are bimodal, and with the help of computer analysis, this has been verified for *Stenella* sp. but is unknown as yet for *Tursiops*. One pair of dentine layers is deposited annually, and age can thus be estimated by tooth analysis, as well as by radiography of flippers. Despite seasonal calving no changes in testis size have been correlated with activity, and it is unknown whether sperm production is continuous or seasonal. Maturity of females is even more difficult to ascertain.

Warren Zeiller, of Miami Seaquarium, mentioned that one female dolphin at Flipper Sea School in the Florida Keys had a stillborn calf each year for 3 years running. Thirteen months elapsed between each calving. Calves that lived have never been produced more frequently than at two year intervals. Twins have once been born in captivity, as stillbirths. One might speculate that the presence of the nursing calf postpones breeding. In the absence of a nursing calf, a period of heat soon after calving would tend to help to compensate for stillbirths.

Much more data are needed concerning the growth pattern and general biology of *Tursiops*. This would best be accomplished if all data and specimens were handled in a centralized place, a permanent registry, such as Armed Forces Institute of Pathology (AFIP) or data storage by International Species Inventory System (ISIS).

C. Causes of perinatal mortality.

The high stillbirth rate (about 25%) is a major problem and has many different causes. There are almost no autopsy data on calves. Examinations have only rarely been done on calves that have been stillborn or young that die. Such information is badly needed if the causes of the high stillbirth and calf mortality rates are to be found and corrected. Occasionally the cause of death is known, e.g., malposition at

birth, inhalation of water with resulting pneumonia, aggression from males, competition from other females, infection. Often the cause of death is obscure. Complete autopsy data, and observation of size, and weight of young are lacking. Knowledge is essential to allow early treatment and prevention. Complete autopsy records are needed and they must be compiled by one agency. It is also not known whether newborns are mature or premature. Studies of these aspects are needed to define maturity. Helpful data would be size, weight, and development of the kidney and other organs. Since some adults have lungworms, the possibility of transplacental transmission (as in bighorn sheep) exists. Examination of histological sections of newborn livers might reveal if transmission happens. It is also necessary to know what antibodies pass to the fetus, particularly since erysipelas is a known cause of death. Observers are divided in their opinion as to the "normal" length of parturition. Times from "minutes" to 1 1/2 hours have been observed. Furthermore, "aunties" have been observed in some colonies but were absent in others. It was generally concluded that offspring should not be removed before 18 months of age, since the maximum death rate occurs before this age. Whether newborns should be vaccinated is another pertinent and unsettled question which needs more study. Occasional abortions have been observed, but little is known about their causes. Several participants suggested that pregnant females should be handled as little as possible.

D. Subspecies

Differences of opinion existed as to the existence of one or more subspecies, an area which requires definition. A "stocky" type is considered to come from Florida and further north, a "slender" type from Caribbean waters. Dr. Hubbs suggested that two Pacific subspecies exist. David Brown, who wrote to the Conference chairman, recognizes an off-shore and a near-shore variety of *Tursiops* off Queensland, Australia. Detailed chromosome banding and electrophoretic studies are needed to delineate the subspecies more precisely. If they exist as different forms, is there a hybrid sterility problem? The area must be investigated promptly to avoid cross-breeding.

E. Endocrinology

Too little is yet known about endocrine data for meaningful analysis. It is believed that dolphins are reflex ovulators, but this is as yet uncertain. It is not known whether the number of corpora albicantia in an ovary reliably predicts the number of past ovulations, but continuing studies by Dr. R.J. Harrison, University of Cambridge, may define this area. He no longer considers these as exactly reflecting the number of pregnancies.

Can *Tursiops* be superovulated and then artificially inseminated? First semen must be obtained and preserved. Initial studies of semen collection are promising. It would be valuable to know whether one can train a male to use an artificial vagina. If so, then the semen could be collected periodically over the course of a year, evaluated and then frozen. Pituitaries should be collected from all cetacea to isolate ultimately enough FSH for radioimmunoassays and for the final purpose of inducing ovulation. Semen has on one occasion been collected from a 180 kg bull by massage. Can the testis size be estimated by sonography and would this be a valid indicator of puberty? Estrogens (E_1 and E_2) and progesterone (P) become elevated in pregnancy, and E_1 seems to be the major estrogen. Whether P levels would be useful in determining ovulation and/or pregnancy ought to be studied. Contrary to the situation in other mammals, testosterone levels appear not to fluctuate from day to night according to one study. More data are needed; quite possibly T-levels could define puberty. Serum collection for ultimate correlation of hormonal data with reproductive studies of events are desirable.

The diagnosis of pregnancy requires study. Close observations by some experienced investigators can lead to this diagnosis but exact timing is difficult. Doppler study of the fetal heart allows diagnosis after the fifth month; fetal heart rate is twice that of mother (usually in left horn). Ultrasonography is possibly the way to go in the future. This would require restraint in a narrow channel, habituation of the animal, and development of a water-tight sensor. Early pregnancy diagnosis is still problematic, and an endocrine approach is most likely to be

successful. Does ovarian senility exist? Or do females remain fertile until death? As yet we have no answer.

F. Nutrition

No unanimity of opinion exists concerning optimal food requirements, and nothing is known of special needs of the female in pregnancy. In particular, needs of trace elements, amino acids and vitamins are not known. Only one serious attempt at producing a totally artificial diet has been made, but more information is needed. Methods of thawing fish need study, as well as what amounts and types of fish to be fed, and whether thiamine or other additives are needed. Fatty livers are frequently observed in dead *Tursiops* but it is not known whether this reflects a deficiency. Dr. J.R. Geraci is willing to undertake tissue analysis of fresh frozen samples of liver. A detailed study of milk is needed as is knowledge of possible additional food requirements for the female during pregnancy.

G. Cost of a breeding colony.

A major obstacle in the breeding of dolphins is the expense involved. Based on his experiences at Marineland of Florida, F.G. Wood estimated that by the time an F₂ generation animal is produced (13-16 years) over one million dollars would have been spent on a breeding colony started with one male and twelve females. These estimates excluded the initial cost of facilities for keeping the animals since a bay pen or fenced-off lagoon area could be used. Close examination of these estimates reveal that they probably are on the conservative side. Therefore, it appears that dolphin breeding in captivity must be limited to the large oceanariums where the animals can be used in public display and education unless great advances can be made in the state-of-the-art of dolphin breeding. Furthermore, the more rapidly the reproductive cycle is understood and the sooner sperm storage, insemination, and ovulation can be achieved, the less expensive the proposition becomes.

H. Mortalities

There is a reluctance on the part of the oceanarium community to provide data on deaths, autopsies, stillbirths, aborted fetuses, and the like because of fear that such data might be used against them by some animal protection groups. A way must be found to pool such data without reference to origin so that it can be used in a positive way. With such assurances oceanaria will be more cooperative.

RECOMMENDATIONS TO MARINE MAMMAL COMMISSION

A. That those portions of the Marine Mammal Act which tend to suppress the establishment of vigorous breeding programs be appropriately adjusted.

1. Relax restrictions of shipment of specimens (e.g., serum, ovaries, tissue for analysis). Allow exchange of animals between breeding institutions.

2. Allow capture of mature animals for serious breeding programs. *Tursiops* caught from the wild for the specific purpose of breeding should be captured from the same herd. Only sexually mature animals should be collected for this purpose. Different breeding strategies should be attempted using different groups of animals:

- a. Captive dolphin colony - in this option, one mature male and several females are put together in a large community tank.

- b. Male dolphins are kept separately, and mature females are placed with them for short periods of time (a month or so) during the spring and fall of the year.

- c. Two mature males are kept together and females are placed with them for short periods of time. This is the way cheetahs have been bred successfully at the San Diego Zoo. Since dolphin males may be aggressive toward each other care must be exercised in this approach.

These are only a few possibilities, but different social groupings should be tried.

B. That cooperative studies between oceanariums and field workers in *Tursiops* population ecology be initiated so that information obtained under captive conditions can be applied to field studies and vice versa.

1. Collect data on births in captivity. A *Tursiops* breeding association has been formed among most of the participants of the Dolphin Breeding Workshop. A form for the request of data has been generated (Figure 1). Mr. John Prescott of the New England Aquarium is acting as secretary of this association. All data should be sent to him. The Commission should encourage this effort and help to sponsor a newsletter on the subject.

2. Provide for central collection of data (e.g., ISIS) and all pathological data through the AFIP Registry of Comparative Pathology.

3. Create a uniform protocol for autopsies, what specimens to collect, what measurements to take, addresses of recipients of data and specimens, to include mother's condition, pool, feed, etc. This may follow a format as shown in Figure 1.

4. Evolve normative data: Prematurity, postmaturity, puberty, causes of death, studbook, animal identification.

5. Create a serum bank to be used for steroid analysis, protein hormone analysis, electrophoresis, and for future reference, e.g., for virus work. Collect all pituitaries (in acetone or frozen).

C. That those conditions of the captive environment most conducive to dolphin reproduction and survival be elucidated (e.g., tank size, handling, vaccinations, behavior, food, etc.).

1. Study optimal breeding conditions: Pool size, water temperature and composition, hierarchy, social structure, and general ethology of dolphin breeding groups, captive and in the wild.

2. Conduct detailed study of nutritional requirements with ultimate aim of commercial artificial diet.

D. That research be conducted to characterize the normal endocrine and reproductive cycles (if any) of *Tursiops* males and females.

1. An urgent problem to be tackled is the need for early pregnancy diagnosis, full characterization of species and subspecies (body measurements, proteins, chromosomes etc.). These studies should include research toward elucidation of the feasibility of semen collection and storage, artificial insemination, superovulation and sonography assessment of testis size.

2. The creation of a serum bank would greatly enhance the development of endocrine data. Moreover the question of transplacental immunity and the development of neonatal infectious disease could be meaningfully investigated (we are not yet sure when a *Tursiops* calf should first be vaccinated).

E. In addition to having these proceedings published and disseminated to the dolphinarium and research groups, it is recommended that similar workshops be sponsored periodically by the Commission. It was considered advisable that the results of the *Tursiops* Assessment Workshop (O'Dell et al.) and those herewith submitted be published together as a hardbound book. Attention should also be drawn to the availability of a study set of the "Histology of the Atlantic Bottlenosed Dolphin" (M22475) by the Armed Forces Institute of Pathology, Washington, D.C.

Figure 1. SUGGESTED SURVEY FORM

Send to: MMC Porpoise Birth Survey
c/o John H. Prescott, Director
New England Aquarium
Central Wharf
Boston, Massachusetts 02110, USA

TURSIOPS INFANT MORTALITY/SURVIVAL (TO 18 MOS.) SURVEY

Calf

Species _____ Date of Birth _____
Name/No. _____ Time-Day-Month-Year _____
Sex _____ Date of Death _____
Parturition Time _____ min. Stillborn? _____
Conceived: Ocean _____ Captivity _____ Other Cause of Death _____

Parents

Female

Male

Species _____	_____
Name/No. _____	_____
Birth Date _____	_____
Capture Date _____	_____
Est. Age _____	_____
Food Fish _____	_____
Health _____	_____
Previous Births (Year & Fate of Calf) _____	_____

(cont'd)

Figure 1 (cont.)

Tank/Pen Data

At Conception:

Shape _____ Dimensions _____ Depth _____
Indoor? _____ Outdoor? _____ Ann. Water Temp. Range _____

Other Animals Present:

Species _____ Adult ♂♂ _____ Adult ♂♂ _____ Juveniles _____
Species _____ Adult ♂♂ _____ Adult ♂♂ _____ Juveniles _____
Socially Established Group? _____

At Birth:

Shape _____ Dimensions _____ Depth _____
Indoor? _____ Outdoor? _____ Ann. Water Temp. Range _____

Other Animals Present:

Species _____ Adult ♂♂ _____ Adult ♂♂ _____ Juveniles _____
Species _____ Adult ♂♂ _____ Adult ♂♂ _____ Juveniles _____
Socially Established Group? _____
Health Problems Around Time of Birth? _____

Previous Births in Tank? _____

Remarks (Incl. unusual behavior, other significant details not included above): _____

Date: _____ Prepared by: _____
Institution: _____
Address: _____

NOTE: This information is to be used for statistical analysis of still-birth and infant mortality/survival data. Identity of institution will not be included in treatment of data. Respondents will be placed on the mailing list for any reports.

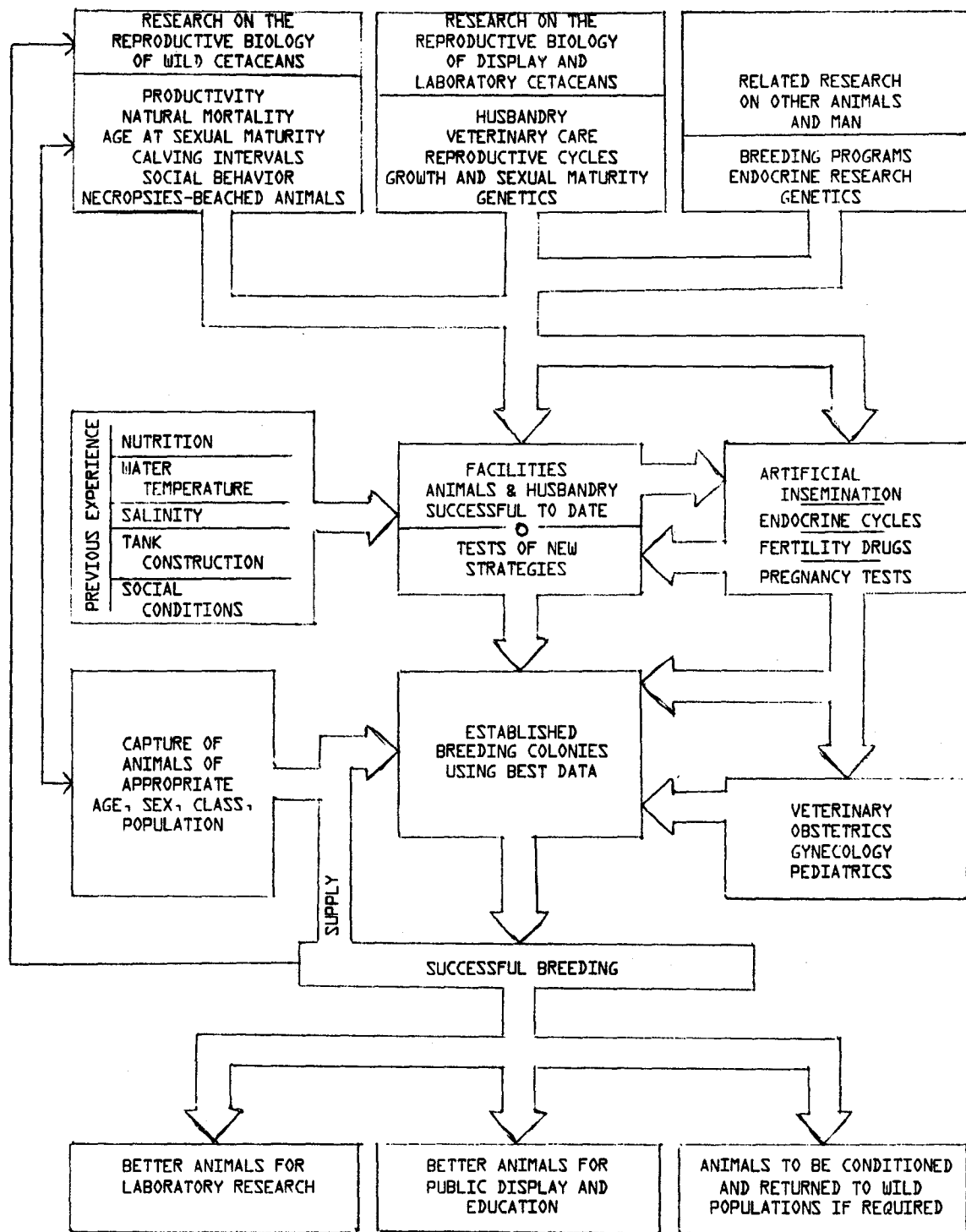


Figure 2. TECHNOLOGY FLOW DIAGRAM

BIRTH OF PORPOISES AT MARINELAND, FLORIDA,
1939 TO 1969, AND COMMENTS ON PROBLEMS
INVOLVED IN CAPTIVE BREEDINGS OF SMALL CETACEA

F.G. Wood
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Marineland of Florida (originally called Marine Studios) opened in 1938, was closed, with the release of all specimens, in 1941 because of World War II, and reopened in 1946. Data on the porpoises maintained prior to 1941 are incomplete, and some information is lacking for the first few years following the reopening. More complete information is available for the period from 1951 to 1963 when I was curator of the oceanarium.

The circular tank in which the porpoises are maintained is approximately 23 m in diameter and 3.7 m deep, with open circulation and a counterclockwise current. Water temperature varies with ocean temperature, sometimes reaching an extreme low of about 13°C in winter, with a high around 27°C in the summer. The population of the tank varies, but from about 1947 to 1963 generally consisted of 1 mature male Atlantic bottlenosed dolphin, *Tursiops truncatus*, 5 or 6 mature females, and several young animals that had been born in the tank. Usually, 1 or 2 spotted dolphins, *Stenella plagiodon*, were also present.

According to available records, 27 porpoises were born in the tank between 1939 and 1963. From 1946, following reopening of the oceanarium, one or more births occurred each year through 1960, except for 1952 and 1957. (There were apparently no births in 1961 through 1964, probably due to the illness or absence of a competent bull.) In 1968 all of the *Tursiops* in the circular tank died of a liver disease (which to my knowledge was never understood), but the performing animals in the stadium tanks survived.

Of the 27 calves born (including 8 stillbirths) between 1939 and 1960, 25 were Atlantic bottlenosed dolphins, 1 was a common dolphin,

Delphinus delphis, and 1 was a spotted dolphin. The latter two were stillborn shortly after their mothers had been captured and will not be considered further in this report. Particulars of the 25 *Tursiops* born prior to 1965 in captivity are given in Table I.

The Bull Porpoise in the Breeding Colony

At least 10 of these calves were sired by a bull named Happy who was captured sometime prior to 1949. In 1953 he weighed 211 kg and measured 2.6 m. When released in 1956 (for undetermined reasons he had begun to attack the females and disrupt the feeding shows) his length was still the same but his weight had increased to 236 kg.

From 1947 until 1960 serious mating activity occurred only in the early spring months - February through May - as evidenced by the birth of calves approximately 12 months later. During his regime as dominant bull, Happy at this time of year was observed to associate with a single female to the exclusion of the others, for periods ranging from a few days to several weeks (Tavolga and Essapian, 1957). Essapian (1963) recorded the dates on which the bull was observed in the company of two different females during March 1954; both gave birth to calves 12 months later.

Following the release of Happy, considerable difficulty was encountered in getting another adult male established in the tank. In the absence of the bull, the largest female, Pudgy, became the dominant animal in the group. On two separate occasions a large male was captured and introduced into the colony. Each time, Pudgy roughly competed for fish thrown to the new arrival, ramming him if he didn't get out of the way and soon reducing him to a thoroughly cowed state. Because it was not possible even to get sufficient food to the males, each had to be removed from the tank and released.

When a third male was brought in he was placed in the receiving tank, called the flume, adjacent to the porpoise oceanarium and given four months to become adjusted to his surroundings. Then Pudgy was moved in with him. She was aggressive at first, clapping her jaws and biting at his flukes, but on the following day no agonistic behavior was observed on the part of either animal. After ten days together, both

were gently herded into the porpoise tank through the connecting gate. Unfortunately, this male died of erysipelas two weeks later.

A fourth male captured at this time was also placed in the flume and given time to adjust. Then, to avoid having to drain the porpoise tank in order to catch Pudgy, the connecting gate was left open in the hope that the new male and the old residents would get acquainted without coming in physical contact. Although porpoises are normally reluctant to pass through a gate, and usually require special training to do so, the new male voluntarily entered the circular tank. He was chased briefly by a female named Mrs. Jones and slapped by her flukes, but within a few hours appeared to have become integrated into the colony.

At no time was consideration given to introducing several adult males simultaneously. In the early years of Marineland it had been found that adult males did not get along with each other in confinement, especially during the spring mating season, and their agonistic behavior was sometimes directed toward other animals in the tank.

Bull porpoises have on other occasions sometimes behaved very aggressively toward infants and their mothers for reasons that are not clear (McBride and Hebb, 1948; Essapian, 1963).

The Females in the Breeding Colony

During the period 1947 through 1960, 4 females accounted for 16 births, with 4 each, all but 2 conceived in captivity. One of the females, Pudgy, later gave birth to a fifth calf in 1966 (D.K. Caldwell, personal communication). Intervals between births ranged from 2 to 4 years (6 years for Pudgy's fifth calf).

One female, Spray, born in the porpoise tank in February 1947, gave birth to a calf in May 1954, March 1956, May 1958, and (D.K. Caldwell, personal communication) in May 1965 and January 1967. Unlike other mother porpoises observed, Spray was distinctly negligent with her first calf. It died at the age of 15 days, undernourished and having suffered a fractured left mandible, although the immediate cause of death was apparently drowning (Tavolga and Essapian, 1957). Spray's second calf, which was stillborn, was unusually large, weighing 16.8 kg and measuring 113 cm. Her third and fourth calves were apparently normal births,

since they were given names, but no other details are available. Her fifth calf was stillborn and recorded as premature.

Another female, Nellie, born in the oceanarium tank in February 1953 and later transferred to the stadium tank where trained animals perform, gave birth to a calf there in June 1967. It died at the age of one year of unrecorded cause (D.K. Caldwell, personal communication).

Only one cephalic presentation, with birth of a normal infant, has been observed (Essapian, 1963). One calf in normal breech presentation is known to have died during parturition, apparently of a strangulated umbilicus.

Details of mating, pregnancy, parturition, and mother infant behavior have been described by Tavolga and Essapian (1957) and Essapian (1963). Earlier accounts are given by McBride (1940), McBride and Hebb (1948) and McBride and Kritzler (1951).

Time of Year Births Occurred

The numbers of captive births, including stillbirths, that occurred at the Florida Marineland from 1939 to 1969 are shown in Figure 1. Prior to 1966, all births took place in the months of February through May except for one, in December 1939, which was recorded as probably premature. There is no obvious explanation why 8 births occurred from August into December only after 1966. Caldwell and Caldwell (1972) found that *Tursiops truncatus* births at other oceanariums both in Florida and on the west coast occurred for the most part in the latter half of the year, but the numbers are inadequate for any firm conclusions.

Infant Mortalities

Of 20 successful births at Marineland (through 1969), 11 calves survived to an age of at least one year. While nursing commonly continues to the age of about 18 months, calves have been observed to take fish as early as 6 months, and at the age of 12 months a calf born in captivity might, with the care and attention it would receive, stand a good chance of surviving should it lose its mother. However, the very high mortality rate of calves captured at an estimated age of one to two years suggests that forcible separation from the mother and introduction into

strange surroundings, with strange companions, cannot be tolerated, even though the animal may be physically capable of surviving on a fish diet.

Although my copies of autopsy reports have been lost (and the originals at Marineland are apparently no longer in the files), it is my recollection that the majority of the calves that died at less than one year of age were victims of erysipelas.

Stillbirths

Records for the period of 1939 to 1963 indicate a high proportion of stillbirths - 8 out of a total of 25. Four of these, however, occurred during the first few years of Marineland's existence. Three of the 4 were conceived in the ocean, and stillbirth may have resulted from the rigors of transport during late pregnancy, although the date of capture of the mothers is not known.

During the period from 1948 to 1963 when 4 of the resident females gave birth to 16 calves, the majority sired by Happy, only 1 was still-born. The other stillbirths during this time were to a female captured 4 months before parturition occurred, to the captive-born Spray (her second), and to a female, Liz II, captured almost 3 years earlier (with her calf which was in poor condition at the time and died within 2 weeks).

According to later (and sketchier) records provided by D.K. Caldwell from Marineland files, Liz II gave birth to another calf 5 years later; it was not identified as stillborn but was also not given a name, indicating demise shortly after birth. Then 2 years later she gave birth to still another which was premature and stillborn.

In 1966, Pudgy, who had previously given birth to 4 healthy infants, 3 sired by Happy and 1 by a male called Neptune II, gave birth to a full-term dead calf which was stated to have been sired by still another male, Little Joe. Little Joe was also reportedly the father of Liz II's premature stillborn calf and Spray's fifth, which was premature and still-born.

DISCUSSION

While a competent, mature, dominant male and healthy, fertile females are a requisite, the reproduction data from the Florida

Marineland suggest other factors that need to be recognized. A stable social group, such as that that existed from about 1947 to 1963, when most of the successful births occurred, appears important. Replacing or introducing additional females to the colony poses no particular problems, but replacing the bull may be difficult. He may be large and sexually mature, but in new surroundings and with strange companions he is at a disadvantage. It is probably an exceptional bull that would quickly exert his dominance under these conditions.

There are a number of indications that personal acquaintance plays an important role in the social behavior of these animals. On a few occasions two porpoises of the same or opposite sex which had been observed to have a close and companionable relationship have been physically separated for a period of time. When reunited they gave every indication of being pleased to see each other, and swam together for several days. The personal relationship factor is not restricted to conspecific animals. On at least two occasions when a male *Stenella* was introduced as a mate for a female spotted dolphin named Dotty who lived in the porpoise tank for 6 years, Dotty, during the initial period of excitement that always resulted from the introduction of a new animal, always swam with her bottlenosed friends. In only one instance she was seen swimming with the new male, briefly, 2 months after he had been placed in the tank.

The data are inadequate, but it appears possible that a particular male may be responsible for stillbirths, as indicated by Little Joe's record.

Only 2 females born in captivity have themselves given birth to offspring. Spray, who had her first calf at the age of 7, was a negligent mother (and possibly deficient in milk), perhaps because of her immaturity. Her second calf, 2 years later, was stillborn (apparently post-term), and her third, again 2 years later, was, according to recollection, better cared for and lived at least several months, but recorded information is lacking. Her fourth, 7 years later, survived for an unrecorded period of time, and her fifth and last calf, 2 years after the fourth, was premature and stillborn.

Nellie, the other captive-born mother, had her first calf in 1965 when she was 14 years old. It lived for 12 months, but other details are lacking. She reportedly has had at least one other calf since.

Of the data available on the *Tursiops* born in captivity within the period 1939 through 1969, 10 out of the 40 were stillborn, one was premature and died within 24 hours, and one died during parturition, apparently of a strangulated umbilicus. Three of the stillborn were recorded as conceived in the stadium and in the research tanks; circumstances associated with maintenance of these tanks might have been responsible for the stillbirths, but information is lacking.

Judging from scattered observations of female porpoises supporting dead infants in the wild and the occasional finding of a dead newborn calf on the beach, it can be speculated that stillbirths are not uncommon in nature, but how the record at Marineland compares goes beyond speculation. Stillbirths at Marineland have been almost equally divided between males and females.

No conclusions can be drawn regarding the viability of males versus females following birth. Nine calves - 5 males and 4 females - are known to have died prior to 18 months of age, but one reportedly died of "injuries", one died of neglect, and most of the others probably succumbed to erysipelas (Table II).

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FIGURE I. *TURSIOPS* BIRTHS (INCLUDING STILLBIRTHS)
AT FLORIDA MARINELAND, 1939 THROUGH 1969.

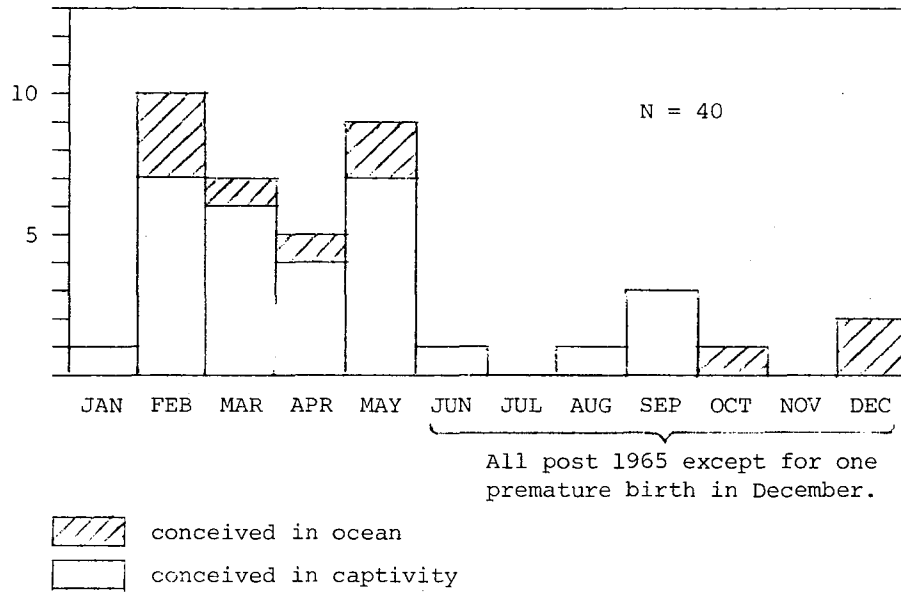


TABLE I. *TURSIOPS* BIRTHS AT MARINELAND
OF FLORIDA 1939 THROUGH 1960.

	MALE	FEMALE	SEX UNKNOWN	STILLBORN	DIED IN PARTURITION
CONCEIVED IN OCEAN 6	2	1	3	4	-
CONCEIVED IN CAPTIVITY 19	13	5	1	4	1*

*strangulated umbilicus

TABLE II. MORTALITY OF *TURSIOPS* CALVES
WITHIN 18 MONTHS FROM BIRTH
(MARINELAND FLORIDA, 1939-69).

SEX	NAME	BORN	DIED	AGE	CAUSE
male	?	23 Apr 48	Oct 48?	6 mo	"Injuries"
female	Mamie	7 Feb 53	13 Jun 53	4 mo, 1 wk	No information
male	Mitch	7 May 53	22 Feb 54	9 mo, 2 wk	No information
female	Peggy	4 Mar 54	19 Mar 54	2 wk	Neglect
male	Rollie	6 Mar 55	28 Aug 55	5 mo, 3 wk	"Starvation?" (Died same day as dam, Mona)
male	Patrick	17 Mar 55	10 Aug 56	14 mo, 3 wk	Erysipelas
male	Mickey	5 May 57	?	2 mo, 2 wk	No information
female	June II	28 Jun 67	?	12 mo	No information
female	Holly	22 Dec 68	15 Feb 69	1 mo, 3 wk	No information

Note: It is possible that a male infant, Salty, born 13 May 1958 to Spray, and a female, June, born 4 May 1965, also to Spray, should be added to the above list, but information is lacking.

TABLE III: *TURSIOPS* BIRTHS AT FLORIDA MARINELAND, 1939 - 1969.

NO.	NAME	SEX	BIRTH DATE	DAM	DATE DAM CAPTURED	CONCEP- TION	PARTUR. TIME (min)	REMARKS
1.	---	?	23 Dec 39	?	?	Ocean	32	Stillborn. Believed premature.
2.	---	?	13 Feb 40	?	?	CT*	405	Stillborn. Term.
3.	---	?	4 Mar 41	?	?	Ocean	567	Stillborn. Premature.
4.	---	?	10 Apr 41	?	?	Ocean	400	Stillborn? Term.
5.	Spray	Female	26 Feb 47	Mona	27 Apr 46	Ocean	23	Term.
6.	---	Male	23 Apr 48	Mrs. Jones	?	CT	21	Term. Died of injuries @ 6 mo. Sire probably Happy.
7.	Algae	Male	8 May 49	Susie	5 May 49	Ocean	117	Died 5 Apr 57 in stadium. Swal- lowed rubber ball.
8.	Frank	Male	12 May 50	Pudgy	Before 11 Apr 49	CT	Not Obs.	Sired by Happy. Moved to MoP 14 Sep 54.
9.	Floyd	Male	15 May 50	Mrs. Jones	?	CT	Not Obs.	Sired by Happy. Moved to MoP 14 Sep 54.
10.	---	Male	1 Feb 51	Mona	27 Apr 46	CT	Not Obs.	Sired by Happy. Stillborn. Term.
11.	Mamie	Female	7 Feb 53	Mona	27 Apr 46	CT	Not Obs.	Sired by Happy. Term. Died 13 Jun 53. Erysipelas.
12.	Maggie	Female	23 Feb 53	Mrs. Jones	?	CT	Not Obs.	Sired by Happy. Term. Died 12 Jul 55. Erysipelas.

*Circular Tank

Table III (cont.)

NO.	NAME	SEX	BIRTH DATE	DAM	DATE DAM CAPTURED	CONCEP- TION	PARTUR. TIME (min)	REMARKS
13.	Nellie	Female	27 Feb 53	Susie	5 May 49	CT	Not Obs.	Sired by Happy. Moved to stadium Apr 57. Still alive Dec 75.
14.	Mitch	Male	7 May 53	Pudgy	Before 11 Apr 49	CT	68	Sired by Happy. Term. Died 22 Feb 54.
15.	Peggy	Female	4 Mar 54	Spray	<u>Born</u> 26 Feb 47	CT	28	Sired by Happy. Term. Died 19 Mar 54. Probably starvation & neglect.
16.	Rollie	Male	6 Mar 55	Mona	27 Apr 46	CT	50	Sired by Happy. Term. Died @ 6 mo same day as Mona. Starvation.
17.	Patrick	Male	12 Mar 55	Mrs. Jones	?	CT	62	Sired by Happy. Term. Ceph. present. Died 10 Aug 56. Erysip.
18.	Phil	Male	9 Apr 55	Pudgy	Before 11 Apr 59	CT	c. 60	Sired by Happy. Term. Died 15 Nov 57. Septicemia- glanders.
19.	Perky	Male	19 Mar 56	Susie	5 May 49	CT	Not Obs.	Sired by Happy? Term. Died 11 Nov 57. Erysipelas.
20.	---	Male	21 Mar 56	Spray	<u>Born</u> 26 Feb 47	CT	Not Obs.	Sired by Happy? Post-term. Still- born.
21.	Salty	Male	13 Mar 58	Spray	<u>Born</u> 26 Feb 47	CT	Not Obs.	Term.

Table III (cont.)

NO.	NAME	SEX	BIRTH DATE	DAM	DATE DAM CAPTURED	CONCEP- TION	PARTUR. TIME (min)	REMARKS
22.	---	Male	19 Feb 59	Dixie	24 Oct 58	Ocean	15-20	Stillborn. Premature.
23.	---	Female	3 Mar 60	Liz II	11 Dec 57	CT	Not Obs.	Stillborn. Term. Sired by Neptune II.
24.	Gordo	Male	22 Apr 60	Pudgy	Before 11 Apr 49	CT	Not Obs.	Term. Sired by Neptune II. Still living Mar 63.
25.	---	Male	25 Apr 60	Susie	5 May 49	CT	47	Term. Died during partur. Strang. umbilicus.
26.	June	Female	4 May 65	Spray	Born 26 Feb 47	CT	48	Sired by Little Joe or Sinbad.
27.	---	Female	18 May 65	Liz II	11 Dec 57	CT	40	Sired by Little Joe or Sinbad. Stillborn.
28.	---	Female	6 May 66	Pudgy	Before 11 Apr 49	CT	273	Sired by Little Joe. Term. Stillborn.
29.	---	Female	12 Sep 66	Splash II	11 Jan 57	Stadium	Not Obs.	Premature? (8 kg). Died within 24 hrs. Sired by Sinbad or Algae.
30.	---	Female	13 Jan 67	Spray	Born 26 Feb 47	CT	Not Obs.	Premature (6 kg). Stillborn. Sired by Little Joe.
31.	---	Female	20 Feb 67	Liz II	11 Dec 57	CT	188	Premature. Still- born. Sired by Little Joe.
32.	---	Female	26 Feb 67	M.S. #190	5 Feb 67	Ocean	Not Obs.	Stillborn. Term?
33.	Mickey	Male	5 May 67	M.S. #206	6 Apr 67	Ocean	Not Obs.	Term. Died @ 2.5 mo. Lungworm.

Table III (cont.)

NO.	NAME	SEX	BIRTH DATE	DAM	DATE DAM CAPTURED	CONCEP- TION	PARTUR. TIME (min)	REMARKS
34.	June II	Female	28 Jun 67	Nellie	Born 27 Feb 53	Stadium	>19	Sired by Algae II. Died @ 12 mo.
35.	---	?	12 Sep 67	?	?	CT	?	Premature. "Torn up". Stillborn.
36.	---	Male	18 Feb 68	Splash II	11 Jan 57	Stadium	?	Premature (est. 5 mo.) Stillborn.
37.	---	?	26 Sep 68	Mrs. Jones	?	Exp. Tank	?	Term. Stillborn.
38.	---	Female	11 Oct 68	M.S. #243	1 Aug 68	Ocean	?	Term. Stillborn.
39.	Holly	Female	22 Dec 68	M.S. #249	19 Aug 68	Ocean	?	Died 15 Feb 69.
40.	---	Male	18 Aug 69	Elise	22 Apr 68	Res. Tank	?	Premature. Stillborn.

MIAMI SEAQUARIUM DOLPHIN BREEDING PROGRAM

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The Miami Seaquarium opened to the public September 24, 1955. On that day a bottlenosed dolphin (*Tursiops truncatus*) female calf was born; optimistically she was named Alpha. She had been conceived in the wild of a dam called Mama (whom one would suspect was so named upon being "recognized" as pregnant). The following is a 20 year chronological listing of *Tursiops* births that were to follow.

Several salient points must be kept in mind by the reader. Early records are sketchy, at best, and husbandry practices purposely were thwarted in areas other than the Main Seaquarium tank by maintenance of animals of one sex. The list as presented undoubtedly will stimulate questions rather than provide answers. Nonetheless, these data are accurate and are provided in the best interests of dolphin breeding research and programs.

Of the total of 23 calves born in Seaquarium captive environments, 16 births occurred in the herd in the one-half million gallon capacity Main Seaquarium. The first was conceived in the wild, the balance in captivity. All of the remaining seven were conceived in the wild of dams captured 12 months or less prior to parturition.

Three sexually immature males were included in the Main Seaquarium herd between 1965 and 1974 and are not considered sires. Notes in early records indicate a male named Bull may have been responsible for births two, three and four. Two adult bulls introduced in 1959 were Pedro and Soapy; the former was removed from the tank in 1963 and the later in 1966. The fourth, Flippy, performed in an area of all male dolphins from his date of capture in 1968 until late 1971. At that time he was transferred to the main tank and sired a succession of seven offspring, the first

approximately 13 months after his introduction to the herd. (One female at "Flipper's Sea School", Grassy Key, Florida, has borne two calves exactly 13 months apart.)

MORPHOMETRIC DATA FOR FLIPPY

Overall length.....	246 cm
Nose to insertion of melon (rostrum).....	9
" " center of eye.....	29
" " " ear.....	36
" " " blowhole.....	34
" " anterior insertion of rt. pect.....	56
" " " " " dorsal.....	115
" " dorsal tip.....	153
" " center of umbilicus.....	116
" " " genital slit.....	156
" " " anus.....	181
Anterior insertion to tip of rt. pect.....	43
Axilla to tip of rt. pect.....	27
Maximum width of rt. pect.....	20
Dorsal base length.....	36
" height (straight).....	24
" " (base to tip over curve).....	44
Fluke width.....	65
" notch to rt. tip.....	34
" maximum depth at peduncle.....	25
Depth of fluke notch.....	5
Girth at blowhole.....	77
" " anterior insertion of rt. pect.....	115
" " " " " dorsal.....	142
" " posterior " " " ".....	129
Girths starting from posterior insertion of dorsal were recorded at twenty (20) centimeter intervals and are as follows:	
20 cm posterior to dorsal.....	106
40 " " " ".....	80
60 " " " ".....	62
Girth at anterior insertion of fluke.....	35

LIST OF *TURSIOPS* BIRTHS AT MIAMI SEAQUARIUM

LOCATION	SIRE	DAM	CALF (SEX)	BIRTH DATE	DISPOSITION AND NOTES
Main Seaquarium	---	Mama (55-58)	Alpha (f)	9/24/55	D. 10/75 No records.
Main Seaquarium	Bull	Sue (55-59)	Bee Bee (f)	10/31/56	Birth depicted in "Life" magazine. Has borne 3 calves and still is performing in Main Seaquarium with herd.
Main Seaquarium	Bull	Clown (55-72)	Francis (f)	3/24/59	D. 1962 First of 3 calves borne of Clown.
Main Seaquarium	Bull	Cha Cha (55-L)	Samba (f)	3/30/59	D. 11/24/64 First of 4 calves borne of Cha Cha.
New York Tank	---	Ernistine (?-?)	---	6/61	Stillborn
9 Main Seaquarium	Soapy or Pedro	Cha Cha (55-L)	Can. Can (f)	8/14/63	D. 9/15/66 Death attributed to erysipelas (diamond skin patches on skin recorded).
Main Seaquarium	Soapy or Pedro	Clown (55-72)	Joker (m)	8/24/63	D. 9/15/66 Death attributed to adult male.
New York Tank	---	Ondine (64-67)	Ski (m)	11/03/64	D. 8/27/70 Death attributed to entanglement in anode cables. Transferred with Ondine (dam) to Main Seaq. 2/25/65 @ 155 cm; 45.5 kg weight.
New York Tank	---	Go Go (66-71)	---	11/11/66	D. 11/14/66 Weight 13.2 kg. Go Go (dam) sold to Gulf Port, Miss. 5/1/71.
Main Seaquarium	Soapy	Clown (55-72)	Spring (m)	5/13/67	D. 12/4/67 Cause of death unrecorded.

List (cont.)

LOCATION	SIRE	DAM	CALF (SEX)	BIRTH DATE	DISPOSITION AND NOTES
Main Seaquarium	Soapy	Bee Bee (56-L)	Genna (f)	6/67	D. 3/28/68 Cause of death unrecorded. Bee Bee's first offspring.
Sea Snow Arena	---	Mama (?-71)	Rascal (m)	10/13/68	D. 6/29/72 A multitude of coins, Australian pinetree cones, etc. were removed from Rascal's stomach upon autopsy and were considered responsible for his demise. Mama was donated to Seaquarium. 4/17/71 went to Barcelona Zoo, Spain.
New York Tank	---	Sam (71-71)	---(m)	8/10/71	D. 8/12/71 Cow rejected calf. 102 cm x 4.8 kg. Sam returned to wild 8/20/71.
New York Tank	---	Patty (63-73)	---(m)	6/07/72	Stillborn. 108 cm x 18.1 kg. Deformed.
Main Seaquarium	Flippy	Cha Cha (55-L)	Samba (m)	12/02/72	Separated from Cha Cha (dam) 8/2/74 @ 111 kg. Performing at Flipper Set.
#4	---	Rene (72-L)	Cricket (f)	3/11/73	D. 12/22/73 174 cm x 60 kg.
Main Seaquarium	Flippy	Bee Bee (56-L)	---(m)	7/30/73	Stillborn. 112 cm x 14.3 kg. Dam's second calf.
Main Seaquarium	Flippy	Dink (67-L)	---	2/21/74	Stillborn.
Main Seaquarium	Flippy	Bee Bee (56-L)	Dawn (f)	8/26/75	Dam's third calf.
Main Seaquarium	Flippy	April (70-L)	Dianne (f)	8/31/75	---
Main Seaquarium	Flippy	Cha Cha (55-L)	Todd (m)	9/03/75	D. 11/3/75 Shock and respiratory arrest while being moved with dam for tank repairs.

List (cont.)

LOCATION	SIRE	DAM	CALF (SEX)	BIRTH DATE	DISPOSITION AND NOTES
Main Seaquarium	Flippy	Dink (67-L)	---(m)	9/06/75	D. 9/7/75 103 cm x 13/6 kg. Cause of death unknown. Dam's second calf.
Main Seaquarium	Flippy	Cathy (71-L)	---(m)	9/11/75	Stillborn.

EXPERIENCES OF SEA WORLD FROM 1963 TO PRESENT
WITH *TURSIOPS* SPECIES REPRODUCTION,
AND SOME PLANS FOR THE FUTURE

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Until recently, Sea World has had no positive program for the breeding of *Tursiops* or any other cetacean in captivity. All births, until about three years ago, were accidental and unplanned. Any pregnancies occurring up to that time were the result of breeding occurring in (1) a feeder pool situation, (2) show areas in the saltwater lagoon, and (3) educational displays. Probably the most significant of these births is the one that occurred in 1968.

An Atlantic bottlenosed dolphin (*Tursiops truncatus*) that spent six years at Pacific Ocean Park prior to coming to Sea World in 1963, gave birth to a male calf on 9/11/68 at 11:00 a.m. The dam, a well-trained show performer, worked regularly until just three days prior to giving birth. The sire was also an Atlantic bottlenosed dolphin brought from Mississippi in 1963. The calf developed normally until 5/21/69 when separation periods were begun. The calf did not eat fish regularly, and as the dam's milk supply dried up he lost more and more weight. He finally died on 8/12/69. Necropsy showed pulmonary congestion and hepatic necrosis, along with a tremendous loss of weight. The dam weighed 205 kg and was over 244 cm in length. In 1970 she was moved to the Naval Undersea Center in San Diego, and is now part of their reproductive study in Hawaii. The lagoon area in which the birth occurred is a very large area containing over 7,570,000 liters of unfiltered Mission Bay sea water, with a normal tidal exchange. There was no form of water treatment in effect in this area at the time. This birth is probably Sea World's most unusual since the parents were both in daily shows and the dam performed daily until just three days prior to giving birth.

On 4/8/73 in a sectioned underwater viewing area of the grotto display, an Atlantic bottlenosed dolphin gave birth to a female calf at 3:30 p.m. The dam was a 182 kg, 232 cm display animal with no history of health problems. She was collected on 4/9/72 somewhere in Florida waters. The sire was not identified. The calf lived until 5/12/73. Necropsy revealed many bruises and minor subcutaneous hemorrhages. The dam was seen abusing the baby at times, and it was felt she had contributed more than a little to the death. Of note is the presence of considerable construction in the area which may have contributed to the uneasiness of the dam. This grotto pool is 12.2 m long, 4.6 m wide, and 3.7 m deep, and contains 200,132 liters of water.

The next birth occurred in an off-exhibit area, a temporary dough-boy type of pool 6.1 m in diameter and 1.4 m deep, containing 53,482 liters. This birth occurred on 5/15/73. The dam, an Atlantic bottlenosed dolphin, was collected on 6/9/71 from Florida waters. She was 220 cm long, and weighed 141 kg when collected, and according to the records was an estimated six years old. On 3/2/73 she was 230 cm long and on 3/20/74 she was 244 cm long; she had no prior health problems. The sire was an Atlantic bottlenosed dolphin, collected and transported to Sea World at the same time as the dam. He was very large, over 244 cm long and 182 kg, and very scarred and old in appearance upon his arrival. At this writing, tooth section aging has not been completed but is underway. The baby thrived until 8/9/73, when the temporary pool lining leaked so badly that the dolphins had to be moved to another area across the park. The move lasted 12 minutes; the baby did well until the last minute, when it went into shock and died.

This female also had another calf on 4/17/75, a planned birth, sired by the same male. This calf, a male, was conceived in the public feeding pool area, and the dam, sire, and one "auntie" dolphin were placed in a newly designated breeding/research pool which is 10.7 m x 2.4 m x 170,325 liters. On 10/9/74 when the female was about 4 1/2 months pregnant, the pregnancy was confirmed by Doppler stethoscope; the fetal heart beat was about 90 per minute. This calf continues to thrive; the calf and mother have been moved to a smaller pool as a

result of expansion of a medical treatment pool and watertight gate insertion in the area of the nursery pool. Their present pool is 5.0 m in diameter, 1.5 m deep, and holds 26,026 liters. As of January 1967, they have been in this pool several months and are doing well. The baby plays with attendants and is fat and healthy.

The remaining births have occurred in Pacific bottlenosed dolphins (*Tursiops truncatus*, c.f. *gilli*). They were all conceived in the public feeder pool, and one was born in this pool. The first was born to a large, aged female collected near San Felipe, Baja California, Mexico, on 8/31/69. She was at the time of collection 330 cm in length and weighed 326 kg. She was and is well adapted and without obvious health problems. The calf was born in a rear holding area pool 10.7 m x 2.4 m x 170,325 liters; it was stillborn. The sire was unknown, but was probably one of three large male Pacific bottlenosed dolphins in the public feeder pool at the time of conception. This female had another calf on 5/12/75 in the breeding/research pool mentioned previously. The dam had been in this pool since 4/25/75, when pregnancy was confirmed by Doppler stethoscope; fetal heartbeat at this time was about 120 beats per minute. The calf, a 111 cm female weighing 13 kg, died on 5/13/75. She had been observed to struggle for air from the time of her birth and was not expected to survive. The seemingly poor production record of this female could well be the result of her age or a genetic factor, or could be simply a reproductive problem as yet undetermined. She continues to be outwardly healthy at this writing.

The last female involved, also a Pacific bottlenosed dolphin, collected from Puertocitas, Baja California, Mexico, on 1/30/71, was 260 cm in length and weighed about 227 kg when collected. She gave birth in the public feeder pool area on 4/17/74 at approximately 6:00 a.m. The calf, a male, was seen nursing at 11:00 a.m. The mother was seen roughly directing the baby away from the edges of the pool several times. The calf died on 4/19/74 at around 12:00 p.m. This female is presently again gravid, as indicated by Doppler examination on 9/16/75; fetal heartbeat of 180 beats per minute was observed. She is presently in a 10.7 m x 2.4 m x 171,325 liter pool with a male Pacific bottlenosed dolphin, a

Pacific whitesided dolphin (*Lagenorhynchus obliquidens*), and a small pilot whale (*Globicephala macrorhynchus*, c.f. *scammoni*). Plans are to move her to a large 18.3 m x 4.0 m x 956,250 liter pool very soon in preparation for the birth.

From these data it can be seen that these animals will reproduce in captivity with some predictable success. It is also evident that interference by excess handling is ill advised, and that to some extent the larger the area provided for birth the greater the chance of success. However, there are also other probable causes for lack of reproductive success. These include nutrition, genetic mismatching, reproductive system malfunctions, infectious processes, and other problems in the newborn itself. Thus we have several large categories of possible interferences, some of which we know nothing about at this time.

PLANS FOR THE FUTURE

The previously mentioned 246,250 liter pool constructed in 1975 is intended to be used for breeding research purposes. Hopefully to be included in this category are *Tursiops*, *Lagenorhynchus*, *Globicephala*, and *Orcinus* at some time in the future. The possibility of other cetacean reproduction will of course always be kept in mind should the opportunity seem available.

At present, the above-mentioned Pacific bottlenosed dolphin, the successful Atlantic bottlenosed dolphins and calf, as well as two other *Tursiops* females are to be located in this pool; along with them will be at least two potential sires, Pacific bottlenosed dolphins, one of whom we know is a successful breeder. This project has been planned for the past couple of years, and its implementation is in progress now. A reproduction project such as this is obviously fraught with unknowns. We do not enter into it lightly but recognize fully the costs of maintaining and feeding the dolphins (about \$300/month each), the extra effort needed in observers, and the capital expenditures (about \$250,000 so far). Additionally, since the animals to be used, at least initially, were not specifically obtained for the purposes of reproduction, they may not be the most desirable subjects. Nevertheless, the potential is available and we intend to be successful.

Currently, there are studies underway for a consistent and frequent examination of blood and tissues for clues to reproductive cycles. Progesterone and other hormone levels have been and will continue to be monitored. Doppler stethoscopy will be used extensively on all female subjects to try and pinpoint conception dates and delivery periods as accurately as possible. Behavioral studies and food intake and preference studies, along with physical examinations, are to be conducted on a scheduled basis. Necropsies will be conducted on all failures, and international reproductive data will be accumulated for the overall picture. The males will also undergo similar scrutiny. Size and weight compilations are in effect presently. Semen samples are to be collected as technique development allows, and the use of artificial insemination is not out of the question.

This is to our knowledge the first time such a positive and extensive program has been applied to cetacean reproduction on a practical basis.

COMMENTS ON CAPTIVE BIRTHS OF *TURSIOPS TRUNCATUS*
AT MARINELAND OF THE PACIFIC (1957 - 1972)

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Marineland of the Pacific opened in 1954 and recorded its first birth of a bottlenosed dolphin (*Tursiops truncatus*) in 1963. Marineland's first exhibit, however, consisted of four bottlenosed dolphins, two of which were captive-born at Marineland of Florida, St. Augustine.

In 1961 it was recognized that Marineland of the Pacific required additional specimens and reserve animals for shows/exhibits, and the first large holding facility for dolphins and whales was constructed. For the continuing existence of an oceanarium facility, a standing population of animals is essential in order to guarantee the quality of exhibits. In the complex of pools, one pool, 21.3 m long by 9.1 m wide and 3.7 m deep, was constructed as a future facility for killer whales; it contained 643,450 liters. From 1962 to 1967 it was utilized as a community facility for dolphins.

The colony consisted of a group of mature, bottlenosed dolphins, *Tursiops truncatus*, and Pacific white-sided dolphins, *Lagenorhynchus obliquidens*. From time to time the community composition varied due to exhibit requirements; however, its basic population consisted of a mature male and four mature female bottlenosed dolphins. From two to four white-sided dolphins were also housed in the facility.

The first birth occurred in 1963. Unfortunately, the calf survived for only 40 hours. The sire of all calves born in the community was Zippy, a mature bull collected in Florida in 1960 and transported to Marineland of the Pacific in 1960 or 1961. Zippy was obtained from Marineland of Florida specifically for breeding. Zippy's weight ranged from 275 to 365 kg, and the two cows, Wave and Amma, were mature females shipped to Marineland in 1960 and 1961.

During the period from 1962 to 1967 four calves were born; only one survived for more than two years. The fate of the others was: the first lived 40 hours, one survived one year, and one was stillborn, death apparently occurred during parturition which lasted more than four hours. Wave and Amma had three of the four calves. The exception was the stillbirth in 1966, and because of some confusion in the records at Marineland of the Pacific, the female parent of this stillbirth is unknown.

In 1967 the dolphin community was interrupted due to the arrival of a killer whale, and the dolphins were moved to other pools. In the summer of 1968 four cows, Amma and Wave, the previous two mothers and two additional adult cows, shipped to Marineland of the Pacific in 1966, were placed in a 9.1 m diameter pool, 1.5 m deep, containing 132,475 liters of water. Marineland of the Pacific's water system utilized water directly from the ocean, and the annual temperature range is 10° to 21° centigrade. Zippy, the same male bottlenosed dolphin who sired the previous births, was introduced into that tank for a 60-day period in September and October. As a result three cows became pregnant. It is unfortunate that all three pregnant cows died in early September, 1969, prior to or during parturition, because of a fatal hepatitis. The fourth, non-pregnant, cow survived.

I believe that this is the first and only experiment when cows of known breeding potential were exposed to a male specifically introduced for a limited time in an effort to achieve breeding. I would like to add that this period of the year was selected as a result of a conversation with F.G. Wood regarding the history of births at Marineland of Florida. He reported that all births at Marineland of Florida had occurred between July 28 and September 12.

The results of the breeding experiments, although not yielding viable calves, have provided some insight into the breeding periods for bottlenosed dolphins. There has been comment on the seasonality of Florida births. The two female dolphins, Amma and Wave, who bore calves between 1963 and 1967 and became pregnant in 1969, were collected along the northeast coast of Florida near St Augustine. The other two females

that were utilized in the 1968 experiment were collected along the west coast of Florida near Tampa by Mr. Nevin Stewart. Thus in one breeding experiment two females from the west coast of Florida and two females from the east coast were utilized.

The bull dolphin, Zippy, although of undetermined origin, is believed to have come from the east coast of Florida. This assumption is based upon the fact that he was collected by Marineland of Florida prior to 1961, and their records indicate that all animals collected prior to that year were from the east coast. Regardless of the source of the male, we have shown that animals from mixed populations have a capability of breeding and becoming pregnant in the fall of the year. It appears to be within reason to assume that a cline exists in the reproductive seasonality of the populations of bottlenosed dolphins in Florida. This may be related to the water temperature variation along the coast of Florida. On the east coast, particularly north of Cape Canaveral, sea water temperatures decrease during the fall of the year. It is conceivable that spring parturition in this area could affect calf survival. It is also possible that animals born in the fall along the east coast of Florida have a lower survival rate. However, these conditions do not exist along the west coast, and water temperatures do not vary as widely.

The loss of the four females in 1969 eliminated the potential breeding program at Marineland of the Pacific. In 1970 a new tank was constructed to replace the previous holding facility which also doubles as a public feeding pool. This tank can best be described as egg-shaped and contains more than 1,135,500 liters of water. A new community of dolphins was re-established, including the male Zippy.

A birth occurred in this tank in 1971, and unfortunately I have no record of the parents except that we know Zippy was the father. At the time of birth, there was a 440 cm female pilot whale included in the community. Shortly after the birth, a great deal of agonistic activity occurred, and the female pilot whale "captured" this calf from its mother. As a result of this problem, the calf succumbed. In 1972 a second calf was born, and for the first time of different parents. The

female Spray, an animal that had arrived at Marineland of the Pacific in 1960 and was trained and maintained in the show exhibit from 1961 to 1970, had been retired and placed in the new exhibit. Stormy, a large male *Tursiops gilli*, was collected specifically for this community, for potential breeding. Their hybrid calf named Dawn still survives, and represents the first record of an Atlantic-Pacific *Tursiops* cross. Spray had a second calf in the summer of 1975, not a hybrid, a new Atlantic male *Tursiops* being the sire. In discussing this birth with Mr. Tom Otten, curator of Marineland of the Pacific, he remarked that Zippy had become very aggressive. In 1972 because of biting and scarring other animals, his teeth were filed. Filing of the teeth apparently allowed a change in the social hierarchy. This change offered a new male, Lobefin, an opportunity to gain dominance. Lobefin's dominance has not been maintained, and Zippy has once again become the alpha male. It is interesting to note that the female, Spray, worked in a show exhibit for more than five years and has had two successful births in five years.

In addition to observations at Marineland of the Pacific, I would like to comment on the experiences of Ocean World, Fort Lauderdale, Florida. These comments stem from personal communications with Mr. Charles Beckwith, president of Ocean World. Ocean World was opened in 1966 with four dolphins captured from a single school. All of the animals were introduced within two days into a large pool, and a fifth female was included. The exhibit facility is a circular tank, approximately 18.3 meters in diameter and 4.6 meters deep, which was designed to provide a jumping show similar to that in the circular tank at Marineland of Florida. It is remarkable that Ocean World experienced births each year from approximately 1967 to 1971. The bull became more aggressive each year and was removed from the exhibit in 1972; no births have occurred since.

It is interesting that the social hierarchy in this pool indicates that a single cow was dominant and was never bothered by the male in an aggressive manner. The male did show aggression to the subordinate cows. The dominant cow gave birth to two calves, and the subordinate three cows had two births during this time. None of the calves survived more than two years.

In summary and conclusion, it is apparent that we know very little about the reproductive and mother/young social requirements of dolphins. Calves at Marineland of the Pacific and at Ocean World have shown the following pattern. If a calf survives the period of birth, and the first 72-hours which appear to be the most critical, it begins picking up its first fish at an age of approximately six months. I have used the term "picking up fish" for it is difficult to assess whether they swallow any significant amount. At approximately nine months they appear to be obtaining about 50 percent of their food from nursing and 50 percent from solid fish. Progressively the calf is weaned until at 18 months nursing appears to be insignificant. I would like to point out that I believe that the social requirements of these animals doesn't necessarily mean that a calf would survive if separated from its mother at the age of nine months to a year. Even though a calf may be capable of surviving nutritionally at as early as 12 months, the importance of the mother/young bond is unknown, and this information we need before adopting a policy of separating a calf from its mother before it is 18 to 24 months old.

With regard to calf survival, there are other considerations. The relationship of stillbirth to the length of parturition appears to be significantly correlated. Difficult births, those in which the parturition period lasts from one and one-half hours to as long as four or five hours, have resulted in the death of the calf. Successful births, and particularly when the calf has survived to more than two years of age, have been those with the shortest parturition periods. There also appears to be a negative correlation between a cow's first birth and calf survival. It is apparent, too, that after parturition there are many unknown factors regarding survival. Some factors that need further clarification are tank size, water temperature, and the relative desirability of isolation and community environments. Successful births have, however, occurred in both community and isolation facilities.

Two factors that have not been discussed but which may be very significant in calf survival are thermal stress and eschelon formation swimming.

What environmental temperatures are necessary for the survival of a neonate? Terrestrial mammal neonates typically rest and sleep during their first few days or weeks. In addition they have the advantage of huddling with litter mates or with the mother. These behavioral patterns conserve energy. The conservation of energy is important. Young animals are provided with a limited or relatively fixed quantity of food. Their nutritional and caloric intake must be converted to growth rather than expendable metabolic energy. Dolphins live in an environment that is an efficient heat conductor, and they must also convert a greater proportion of energy to activity and heat production. Even if a dolphin is born with an adequate blubber blanket for thermal protection (and the evidence is to the contrary, their blubber layer not being as thick as in adults) their loss of heat to the environment is greater than that of an adult because they have a greater surface area-to-mass ratio.

Tank size may also be related to an excessive expenditure of energy since it affects eschelon swimming. Eschelon swimming, more commonly observed and known as bow riding, is an important resting mechanism for baby dolphins and permits the conservation of energy. Eschelon swimming is dependent on distance, or swimming without unnecessary interruption. To be most effective, eschelon swimming requires gradual turns or straight swimming patterns. Every time a sharp turn is made, the eschelon pattern is broken, and for a calf this will require the expenditure of additional energy in order to maintain its position. The smaller the tank size, the more turns will be required, and the result will be greater swimming effort and consumption of energy. Consumption of energy for swimming reduces that available for growth or the development of thermal insulation. Unnecessary interruption of the normal routine of the cow and calf by crowds of people, photographers, etc., may also cause a breakdown in the mother/young swimming formation. Although these factors have not been recognized, several cases of infant pneumonia have been reported, and it is worth considering that neonatal death may be the result of thermal stress or an excess expenditure of energy.

DOLPHIN BIRTHS AT SEA LIFE PARK

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INTRODUCTION

Sea Life Park is a moderately sized oceanarium located at Makapuu Point on Oahu, Hawaii. Sea Life has two show tanks: the Ocean Science Theater, a glass walled tank of approximately 757,000 liters and Whaler's Cove, a free formed gunite tank of nearly 5,677,500 liters. In addition there are six training tanks ranging in size from 41,635 liters to 1,287,700 liters that are used to house dolphins. Backup animals, breeding animals, pregnant and nursing animals, new animals and animals undergoing medical care are kept in the training tanks. Under normal circumstances, animals of only one species are kept in a tank, however, during weekly tank cleaning or under special circumstances species are mixed.

Several species of dolphins are kept at Whaler's Cove. The normal complement includes six to eight spinner dolphins (*Stenella longirostris*), three bottlenosed dolphins (2 *Tursiops truncatus*, 1 *Tursiops gilli*), two false killer whales (*Pseudorca crassidens*) and one pilot whale (*Globicephala macrorhyncha*). The numbers do vary from time to time depending upon the show requirements and the health of the animals. Whaler's Cove is divided by a series of fences and gates so that not all species are together at the same time. This is to prevent problems of interspecific aggression. There are periods of time (for example, tank cleaning), however, when they are all kept in the same pen.

Ocean Science Theater consists of a large main tank with two holding tanks, each of which is divided into two smaller tanks. The number of species at Ocean Science Theater varies with the makeup of the show and the health of the animals but there are always at least two species

(*Steno bredanensis* and *Tursiops gilli* or *Tursiops truncatus*). During the daytime, most animals are kept in their individual pens and released for their part of the show. Unless there is a particularly aggressive animal, all are normally allowed access to the show tank at night.

EXPERIENCES

In order to more clearly understand the problems of breeding and rearing young at Sea Life Park we have divided the problem into five separate areas: conception, pregnancy, birth and the days immediately following, the first month and the six months following.

Conception

Of the ten births at Sea Life Park, eight have resulted from conception in captivity. The remaining two were Atlantic bottlenosed dolphins that were captured in Mississippi and transported to Hawaii. These were obviously pregnant at the time of capture. Of these eight conceptions four were under show conditions and four were of animals kept in the training area. Of the four show conceptions, three were of *Stenella* at Whaler's Cove and one was a Pacific *Tursiops*, also of Whaler's Cove. The four non-show conceptions were two Atlantic *Tursiops*, a Pacific *Tursiops* and an Atlantic *Tursiops-Steno bredanensis* hybridization.

Pregnancy

As far as we know we have only lost one calf during pregnancy. This was nearly a full term *Stenella* calf. We were not able to ascertain the cause of death, but the dam had been sickly for some time prior to the miscarriage. The remaining nine successful pregnancies included two *Tursiops* that were shipped from Mississippi three months prior to parturition, a Pacific *Tursiops* that was used in the Whaler's Cove show (she performed a 6.1 m high rise) nearly to the day she gave birth and several animals that were carried on stretchers and moved from tank to tank prior to giving birth.

Birth

Sea Life Park has suffered its greatest losses at birth and in the few days immediately following. Two of our calves died at birth. The

first, a *Stenella* had an obvious birth defect. The calf had a curved spine and delivery was exceedingly difficult. The other was a Pacific *Tursiops* and was born in Whaler's Cove. The delivery was extremely difficult, taking several hours. The calf was dead at birth and appeared fully developed and normal. We were not able to determine the cause of death.

The same Pacific bottlenosed gave birth two years later. This time we had removed her from the show tank and placed her in a separate training tank. On this occasion the birth was much simpler and the calf was born without complications. The calf appeared healthy and swam normally. It never, however, was seen to nurse successfully. It died two days after birth. Examination of the calf and later the mother indicated that the mother probably had no milk.

First Month

Two calves were lost during this period of time. Both of these were Atlantic *Tursiops*. Both births were normal and the calves seemed healthy. Both births were not, however, under ideal conditions.

In the first case the dam seemed very rough with her calf, often pushing it around the tank. She eventually became very rough, repeatedly pushing the calf up into the air and then underwater. Autopsy showed the offspring's diaphragm to be torn, but whether the dam's action was the direct cause of the death or whether the dam's action was caused by some irregularity in the calf could not be determined.

The other calf was unfortunately born in a tank with two adult males and another adult female. One of the males "adopted" the calf and would not give it to the dam. The other female also spent a great deal of time with the calf while the remaining male ignored it. The dam was the least dominant in the group and was only successful in recovering her calf for brief periods of time.

Following Six Months

Once Sea Life Park's calves have passed the previous stages we have not had problems other than the normal problems of infection.

The first of our calves to reach this stage was a *Tursiops-Steno* hybrid. It was born in a small tank with low water and in the presence of two other females. During the first few hours, until the dam and calf could be separated from the other females it appeared that one of the two females and the dam were competing for the calf. Fortunately the dam was very dominant and did not let the other female interfere. We were soon able to separate the dam and calf from the other females.

The second successful birth (*Tursiops*) occurred three weeks prior and in the same tank as the dam who lost her calf after two weeks. This female was much more attentive to her young. After the other calf died there was no obviously hostile action from the dead calf's dam towards the living calf and no hostility between the females. There was, however, a considerable amount of rough play in which it seemed that the calf could easily be hurt or washed out of the tank. Fortunately this did not happen.

The third successful birth was a *Stenella*. The dam was suspected of being pregnant six months prior to birth and was removed from Whaler's Cove and placed in one of our largest training tanks with several other spinners. Although she was not worked and was fed all she wanted, she was handled on several occasions for examination. Although we were reasonably sure she was pregnant, examinations revealed no sure indication of it. Fortunately, although we considered it on several occasions, we did not return her to the show. It became obvious that she was pregnant only two to three weeks before birth.

During the first week of the calf's life it was frightening to watch the activity in the tank. There was considerable amount of rapid swimming when another female would swim with the calf and the dam would chase after them. This appeared to be an analogous situation to the previously mentioned *Tursiops* birth in the tank with two males and another female. Fortunately the female *Stenella* was a dominant animal and seemed in control of the situation most of the time. The other *Stenella* were all females. There was, however, an additional complication in this case. All of the animals seemed particularly nervous and became easily alarmed when a person would approach the tank. We had to be extremely careful that no one approached the tank. During the first week we kept a 24 hour watch on the tank.

Our most recent birth was a male Atlantic *Tursiops*. It was obvious that the female was pregnant long before she gave birth so she was put into a tank by herself. The birth was uneventful.

The first two weeks of the calf's life were unique. The calf did not react like our previous calves. Each time the mother would slow down, the calf would drift to the bottom, roll over on its left side and stop. The mother would nudge it with her pectoral fin and it would begin swimming again. This happened many times during the first two weeks, sometimes when the mother slowed down and other times the baby would drift away on its own.

After the initial few weeks the unusual behavior occurred less frequently. At this writing the calf appears normal.

DISCUSSION

Conception

It is obvious that dolphins can be bred under captive conditions. We have heard it said many times that conception will not occur under show conditions. Our experience indicated that this is not entirely true. We do feel, however, that several criteria must be met before conception can occur.

The first is obviously that mature animals be present. This is not the case in many situations and is probably one of the reasons no births occurred during Sea Life Park's first seven years and have occurred infrequently during the early years of other oceanaria. Most trainers prefer young animals, both for trainability and lack of aggression. Older mature animals are not as desirable.

Health is also of major importance, both physiologically and psychologically. Psychological health is much more difficult to define. Stress is certainly a factor. We have often heard it said that show animals do not conceive. Although our data show otherwise the hypothesis does appear to have some validity. We feel it is a matter of degree. Our Whaler's Cove tank is large and we do not ask a great deal of our animals. All of our conceptions that have occurred in a show situation have occurred in this tank. This contrasts with Ocean Science Theater

where the animals are worked harder and the tank is smaller. No conceptions have occurred at Ocean Science Theater.

Physical contact is obviously essential, but constant contact appears not to be necessary and may even be detrimental. Females have been impregnated by males they have only met during tank cleanings.

Pregnancy

Like conception this does not appear to be difficult under captive conditions. We have moved animals about on stretchers and have shipped them from as far away as Mississippi with no adverse effects. Females have also carried calves to full term while working in shows. Show stress may, however, have an adverse affect on the psychological well being of the dam that may make birth or the raising of the calf difficult. This will be discussed in the next section.

Birth

It is difficult to determine the true cause of the problems we have had at birth and the days immediately following. We feel that show stress may be partially to blame for two of our losses. It certainly seems plausible that lack of lactation and a difficult birth may have been caused by this stress.

First Month

The loss of calves during the first month is also difficult to explain. It is apparent that there is considerable interaction between adults and between other adults and the young. Dams who are dominant animals seem to have a better chance of successfully rearing their offspring. Large tanks would also appear to be beneficial. This would enable the mother and calf to avoid some of the potentially serious interactions.

Following Six Months

This period of time has not been difficult at Sea Life Park. Normal health care appears to be the most critical factor. We have heard it said that calves should not be handled during the first year. We have

elected to be cautious and not to handle our young dolphins so we do not know if leaving them alone is important.

CONCLUSIONS AND RECOMMENDATIONS

From our limited data we can say little with a high degree of certainty, but there are several factors that appear to be important:

1. In order for conception to occur it is essential to have healthy, mature dolphins.
2. Excessive stress (e.g. from shows) should be avoided both prior to conception and in the months prior to birth.
3. Birth should occur in the largest tank possible.
4. Where possible, near term females should be kept alone. This is not possible with some species such as *Stenella*.
5. Dam and calf should be unmolested.
6. A RELIABLE SIMPLE PREGNANCY TEST SHOULD BE DEVELOPED.

DOLPHIN BIRTHS AT SEA LIFE PARK

DATE OF BIRTH	SPEICES	NAME	SEX	DAM	SIRE	CONCEP- TION	DATE OF DEATH	CAUSE OF DEATH
7-08-71	<i>Stenella longirostris</i>	-----	Female	Tita	-----	Captive	7-08-71	Dead at birth. Deformed spine.
10-04-71	Hybrid <i>S. bredanensis</i> - <i>Pacific Tursiops</i>	Mamo	Female	Makalani	Amiko	Captive	9-27-75	Twisted intes- tine.
8-25-72	Hybrid <i>Atlantic Tursiops</i> - <i>Pacific Tursiops</i>	-----	Female	Apo	Probably Amiko	Captive	8-25-72	Not known.
3-26-73	<i>Stenella longirostris</i>	-----	?	Tita	?	Captive	3-26-73	Premature.
3-29-73	<i>Atlantic Tursiops</i>	Kaleo	Male	Kainui	?	Wild	-----	-----
4-07-73	<i>Atlantic Tursiops</i>	-----	Male	Ilima	?	Wild	4-17-73	Not known.
5-09-74	<i>Atlantic Tursiops</i>	-----	?	Pupuka	Probably Amiko	Captive	5-26-74	Not known.
8-29-75	<i>Pacific Tursiops</i>	-----	Male	Apo	Amiko or Mikimiki	Captive	8-31-74	Dam had no milk.
9-08-75	<i>Stenella longirostris</i>	Pomaikai	Female	Komohana	Kamai	Captive	-----	-----
3-23-76	<i>Atlantic Tursiops</i>	Keola	Male	Kainui	Amiko	Captive	-----	-----

DOLPHIN REPRODUCTION IN OCEANARIA IN
AUSTRALASIA AND INDONESIA

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INTRODUCTION

Australasia is defined as the islands of the South Pacific including Australia, New Zealand, New Guinea, and adjacent islands. In this Paper the islands of Indonesia are also included both because of the close proximity of Indonesia to Australia and New Guinea and because Indonesia has a new oceanarium. This then affords an opportunity for the author to report on reproductive information obtained while working at Jaya Ancol Oceanarium located in Jakarta, Indonesia. The author has also worked in New Zealand as manager of Marineland of New Zealand located in Napier, New Zealand. However, information on Australian oceanaria has been provided in the most part by correspondence. The author has personal knowledge only of the Marineland of South Australia.

CETACEANS REPORTED FROM AUSTRALASIA AND INDONESIA¹

I Baleen Whales

A Family Balaenidae

A ₁₁ NZ ₁₁	<i>Eubalaena glacialis australis</i>	southern right whale
A ₁₁ NZ ₁₁	<i>Caperea marginata</i>	pygmy right whale

¹ taxonomy followed is that of Nishiwaki (1972)

I= Indonesia

A= Australia

NZ= New Zealand

Subscript refers to reference. (This list is most likely incomplete. Only those species for which a reference could be found are noted.)

B Family Balaenopteridae

A ₁₁ ^{NZ} ₁₁	<i>Balaenoptera acutorostrata</i>	little piked or minke whale
A ₁₁ ^{NZ} ₁₁	<i>Balaenoptera bonaerensis</i> ^{2,3}	New Zealand piked whale
I ₁₃ A ₁₂ ^{NZ} ₁₂	<i>Balaenoptera borealis schlegeli</i>	sei whale
A ₁₂ ^{NZ} ₁₂	<i>Balaenoptera edeni</i>	Bryde's whale
I ₁₃ A ₁₂ ^{NZ} ₁₂	<i>Balaenoptera physalus quoyi</i>	southern fin whale
I ₁₃ A ₁₂ ^{NZ} ₁₂	<i>Balaenoptera musculus intermedia</i>	southern blue whale
A ₁₂ ^{NZ} ₁₂	<i>Megaptera novaeangliae lalandi</i>	humpback whale

II Toothed Whales

A Family Physeteridae

I ₁₃ A ₁₂ ^{NZ} ₁₂	<i>Physeter catodon</i>	sperm whale
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B Family Kogiidae

A ₁₂ ^{NZ} ₁₂	<i>Kogia breviceps</i> ²	pygmy sperm whale
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C Family Ziphiidae

A ₁₂ ^{NZ} ₁₀	<i>Berardius arnuxi</i>	southern beaked whale
A ₁₂ ^{NZ} ₁₀	<i>Hyperoodon planifrons</i>	southern bottlenosed whale
A ₁₂ ^{NZ} ₁₀	<i>Ziphius cavirostris</i>	Cuvier's beaked whale
NZ ₁₀	<i>Tasmacetus shepherdi</i>	Tasman or Shepherd's beaked whale
A ₁₂	<i>Mesoplodon pacificus</i> ⁴	Longman's beaked whale
NZ ₁₀	<i>Mesoplodon hectori</i> ⁵	Hector's beaked whale
A ₁₂ ^{NZ} ₁₀	<i>Mesoplodon layardi</i>	strap-toothed beaked whale
A ₁₂ ^{NZ} ₁₀	<i>Mesoplodon bowdoini</i>	Bowdoin's or Andrews' beaked whale
A ₁₂ ^{NZ} ₁₀	<i>Mesoplodon grayi</i> ²	New Zealand scamperdown or Gray's beaked whale
A ₁₂	<i>Mesoplodon densirostris</i>	Blainville's beaked whale

² indicates those animals personally observed by the author.

³ may be synonym of *B. acutorostrata*₁₂.

⁴ may be synonym of *Hyperoodon planifrons*₁₁.

⁵ may be synonym of *B. arnuxii*₁₁.

D Family Delphinidae

I ₁₉ A ₁₂ NZ ₁₂	<i>Lissodelphis peroni</i>	southern right whale dolphin
A ₁₂	<i>Lissodelphis borealis</i>	northern right whale dolphin
I ₁₂ A ₁₂ NZ ₁₂	<i>Delphinus delphis</i> ^{2,7}	common dolphin
I ₁₉	<i>Delphinus capensis</i> ²	cape dolphin
I ₁₉	<i>Stenella melayana</i> ²	Malayan dolphin
I ₈ A ₁₉	<i>Stenella longirostris</i> ²	long-beaked dolphin
NZ ₄	<i>Stenella caeruleoalba</i>	blue-white dolphin
I ₂₅ NZ ₄	<i>Stenella attenuata</i>	short-beaked or kiko dolphin
NZ ₁₂	<i>Lagenorhynchus obscurus</i> ²	dusky dolphin
A ₁₂	<i>Lagenorhynchus fitzroyi</i> ⁶	hourglass or Fitzroys' dolphin
A ₁₂ NZ ₁₂	<i>Lagenorhynchus cruciger</i>	southern white-sided dolphin
I ₇ A ₁₂ NZ ₁₂	<i>Tursiops truncatus</i> ²	bottlenosed dolphin
I ₁₂ A ₁₂	<i>Tursiops aduncus</i> ²	bottlenosed dolphin
I ₂₂ A ₁₂	<i>Sousa plumbea</i>	plumbeous dolphin
I ₁₉	<i>Sousa borneensis</i>	Bornean white dolphin
I ₁₉ A ₁₈	<i>Steno bredanensis</i>	rough-toothed dolphin
NZ ₁₂	<i>Cephalorhynchus hectori</i> ^{2,8}	Hector's dolphin
I ₁₉	<i>Lagenodelphis hosei</i>	

E Family Orcaellidae

I ₁₉ A ₁₉	<i>Orcaella brevirostris</i> ^{2,9}	Pesut or Irrawaddy River dolphin
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F Family Phocaenidae

I ₁₂ A ₁₂ NZ ₃	<i>Neophocaena phocaenoides</i> ²	finless black porpoise
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⁶ may be synonymous with *L. obscurus*₁₂.

⁷ there may be two species of *Delphinus* in New Zealand waters₂₃.

⁸ Oliver describes a piebald variety *Cephalorhynchus hectori* subsp.

⁹ considered to be synonymous with *O. fluminalis*₂₇.

G Family Grampidae

I₂₁^A₁₂^{NZ}₁₂ *Grampus griseus* Risso's dolphin

H Family Globicephalidae

A₁₂^{NZ}₁₂ *Globicephala melaena edwardi*^{2,10} southern pilot whale
 I₁₂ *Globicephala macrohyncha* shortfinned blackfish
 I₁₂^A₁₂^{NZ}₁₂ *Orcinus orca* killer whale
 A₁₂^{NZ}₁₂ *Pseudorca crassidens* false killer whale
 I₁₈^A₁₂ *Peponocephala electra* many-toothed blackfish

BIRTHS AND REPRODUCTIVE INFORMATION FROM MARINELAND OF NEW ZEALAND

DELPHINUS DELPHIS

General

The *Delphinus delphis* kept in captivity at Marineland of New Zealand, Napier, are caught in Hawks' Bay. Napier lies on the shores of Hawks' Bay, and the oceanarium is located on the beach, with pods of dolphins frequently swimming past within 25 meters of Marineland's dolphin pool. Pairing of *Delphinus delphis* in Hawks' Bay has been seen between spring and autumn (late October to the middle of March) with the peak of activity in mid-summer between January and February. Mating in Hawk's Bay has been observed and the following account is typical.¹¹ In a pod of *Delphinus* there is usually a leader or "boss" bull who will mate with several females during an observation period. In one period of 1 1/2 hours at least 25 females mated with the one bull. Essapian (1962) recounts 3 successive copulations with intervals of 15 minutes. Pre-copulatory behavior has consisted of the "boss" bull riding the bow wave of the observation boat (the boat must keep to a speed of less than 4 knots), belly down while several females, one at a time, would rub themselves along his underside, rolling over and swimming on their backs allowing their undersides to rub along his belly. Within a short time he would satisfy all comers. Each mating took only 2 1/2 to 3 minutes.

¹⁰ Nishiwaki (1972) considers the South Pacific pilot whale *G. macrohyncha*. Here Gaskin (1972) is followed.

¹¹ This account was reported to the author by Mr. Frank Robson₂₃.

Mating is usually vent to vent with female underneath. At times the adult females would bring over a young female and it was obvious, at least to the observer, that by their actions they were encouraging her to mate with the bull. This mating behavior is distinguished from a pairing behavior whereby one female and mature but younger male go off with another such pair approximately 100 yards from the main pod where mating will then take place. These mating pairs apparently do not feed during this time which can last up to 30 hours, but they keep in constant communication with the main pod, as they make any and all changes of course made by the pod.

Reproductive Information

A number of apparently old females have been found pregnant, and it is thought that they may be able to conceive up until death from old age. Calves are seen from July to January, with a peak in November, after a gestation period of 10-11 months. Between 1970-1973 several hundred *Delphinus* were killed inadvertently by trawl nets, and 25 percent of the females examined were carrying fetuses while lactating (Essapian, 1962). This agrees with Sleptsov's (1940) observation of *Delphinus* in the Baltic that they mate 1 1/2 to 2 months after parturition, delivering one calf a year. Sleptsov (1940) reports that after 3 years there is a barren year. Calves at birth have been reported to be from 75 to 90 cm long (Harrison, 1969). Those recorded at Napier Marineland were 86 and 97 cm long with a weight of 6.8 and 7.9 kg respectively. The young in Hawks' Bay are thought to suckle for approximately 10 months (Robson, personal communication). (Sleptsov (1940) reports a lactation period of 5-6 months.) The first supplementary food is squid which is taken at about 6.5 months of age when the dolphins weigh about 30 kg. When weaned the young are 1.5 meters long and weigh about 40 kg. The longest adult measured was a male 2.6 m long.

Births in Captivity - Marineland of New Zealand

There have been 2 calves born at Marineland of New Zealand. Both were conceived in the wild. The first calf was born November, 1965. It was stillborn (malformed) and measured 96.5 cm long, had a maximum girth of 45.7 cm and weighed 7.9 kg.

The second calf was born at 1600 hours, July 26, 1968. The mother, "Bess", had been captured in March 1968 in Hawks' Bay. A large male, "Joe", was captured at the same time from the same pod. At birth the calf was estimated to be 86 cm long with a girth of 40 cm and a weight of 6.8 kg. Detailed observations were made during the birth (Robson, personal communication) and a general account follows.

A few days before the calf was born, Bess became noticeably wider and deeper in the after part of the body. On the morning of the birth she did not feed, but accompanied by Joe she cruised steadily around the pool. In this pool were 7 dolphins in all, some *Delphinus* and the other dusky dolphins, *Lagenorhynchus obscurus*. They were in a kidney-shaped pool approximately 5 meters x 15 meters and 2 m deep, as the main dolphin pool was being renovated. During the afternoon feeding time all the dolphins except Bess and Joe began swirling excitedly around the pool. A few minutes later Bess was noticed rolling and arching her back in deep water near one end of the pool, and a female dusky dolphin kept getting underneath and supporting her. When about 30 cm of the tail of the calf had emerged the tail began to beat steadily up and down in the water, and the flukes quickly spread open and stiffened. As Bess continued to have contractions several more centimeters of the calf emerged and the tail beat lengthened. This procedure continued at short intervals, and each time more of the calf was released and held there temporarily by the mother arching her back for a short period. During these intervals the freed part of the calf's body continued to move quite steadily. When the dorsal fin and the flippers were released they were soft and flabby but they quickly became firm, aided by the continuous movement of the calf's body. Joe remained quietly watching Bess from about 3 meters away and he did not attempt to interfere. When the calf was released nearly to the blowhole, the "midwife", Dolly, a dusky dolphin, apparently bit the umbilical cord. The mother released the calf and helped it to the surface, then she and the midwife nuzzled it around on the surface until it began to breathe and swim with the mother. The calf swam very close to Bess, and her flipper partly supported it. At this time the placenta came away naturally. Dolly was next replaced

by another *Delphinus* female who took over the job of auntie. The calf began nursing in 2 to 3 hours after birth and fed about every half hour for the first few days. At 12 weeks after the birth the male Joe tried to copulate with Bess, and it is conceivable that the calf was injured during this flurry of activity. The calf died at 16 weeks of age from pneumonia. At the time of birth the calf was 117 cm long and weighed 14.5 kg. The mother died soon afterwards, also from pneumonia. She was 2 meters long and weighed 94 kg.

LAGENORHYNCHUS OBSCURUS

Lagenorhynchus obscurus are found in Hawks' Bay but are not as numerous as *Delphinus delphis*. They are seen with young from September to January (Allen, personal observations). There have been no births in captivity in New Zealand but the author was fortunate to find a neonatal *Lagenorhynchus obscurus* on the beach in front of Marineland of New Zealand while the adult animals were still hanging about in the surf. The animal had just come ashore. The date was September 17, 1974. The remains of the umbilicus were still present and pressure marks were seen on the skin. The flukes were firm and uncoiled. Whiskers were present in the crypts with 5 crypts on the right (3rd whisker from front missing) and six on the left (all whiskers present). After morphometrics were taken an autopsy was performed. The lungs were pink and appeared to have been inflated with air, and all organs were grossly normal. The length was 92 cm, with a maximum girth of 62 cm and a weight of 12.7 kg. See appendix 1 for complete list of morphometrics.

General Reproductive Information

Reproductive information from *Lagenorhynchus obscurus* kept at Marineland of New Zealand are given in Table 1.

BIRTHS AND REPRODUCTIVE INFORMATION FROM JAYA ANCOL OCEANARIUM

ORCAELLA BREVIROSTRIS

Orcaella brevirostris, known generally as the Irrawaddy River dolphin, is found in the Java Sea and far upstream in the rivers of

Kalimantan. Observations in the Mahakam River, 200 km from the coast, have indicated that births occur during the rainy season, December to February.

Length at birth is reported by Anderson (1878) to be 90-100 cm. He reports a 2.1 m female with a full-term fetus 85 cm in length. A calf 105 cm long was caught in Kalimantan, February 1974. This animal was caught by fishermen but released on October 15, 1974 by a capture team from Jaya Ancol Oceanarium. Young calves were seen in Lake Semayang of the Mahakam River during a February 1974 capture expedition. Those *Orcaella* now in captivity at Jaya Ancol Oceanarium (2 males and one female), have a length from 1.8-2.6 m and weigh 125-200 kg. They began to exhibit sexual activity in December 1974, two months after being transported to Jaya Ancol Oceanarium. This ceased in February 1975 and was resumed the following November 24th. Testes of three male *Orcaella* which died soon after being transported to the Oceanarium, were approximately 700-800 gm each. These animals were 1.9, 2.0 and 2.1 meters in length, and subsequent histologic examination of the testicles showed them to be mature but with only a small number of sperm being produced.

Homosexual behavior has been observed between the two male *Orcaella*. Generally, one male takes his turn to rub the other male with his beak and body, concentrating on the genital area. There is also a behavior which has been termed "kissing". One male touches his beak, sometimes with mouth slightly open, on the neck area of the other male. (These animals have a pronounced neck region.) This behavior occurs so frequently that it appears to have special significance. Only the males have been seen doing this to each other, sometimes with erections. Since the female is smaller than the two males it is possible that she is not yet sexually mature.

TURSIOPS ADUNCUS

On July 9, 1975, a mature female *Tursiops aduncus* was captured by Jaya Ancol Oceanarium. On July 25, 1975, she aborted a near term fetus 60.3 cm long and weighing 2.8 kg. The mother was 1.9 meters long and weighed approximately 100 kg. The mother died approximately 8 hours

later, and postmortem revealed a massive area of cerebral hemorrhage apparently caused at the time of original capture. She had exhibited signs of C.N.S. disease, and treatment for an encephalitis was instigated 5 days before she aborted. On the evening of July 24 she exhibited frenzied swimming and smashed several times into the sides of her pool. The next evening the placenta was noticed hanging from her vagina. When approximately 50 cm of the placenta was protruding the fetal flukes could be palpated inside the vagina. The membranes had not ruptured. After waiting 1 1/2 hours from when the placenta was first noticed, it was decided to interfere. The membranes were ruptured and the fetus was extracted. The mother had only feeble uterine contractions and when the fetus came out the mother vomited. The fetus was stillborn. A complete list of morphometrics of the fetus are given in appendix 2.

The placenta came out with the fetus. It weighed 500 gm and the allantois contained approximately 1.5 liters of fluid. The umbilical cord was detached where it attaches to the fetus, leaving only a 1 cm umbilical opening, when the fetus was delivered. The umbilical cord was 20 cm long and 1.5 cm in diameter. The measurements of the placenta are listed in appendix 3.

The mother's uterus had extensive submucosal edema, was hyperemic and contained 300 ml of blood. The weight of the uterus was 1.5 kg. The left horn was 40 cm long and 11 cm in diameter. The right horn was 33 cm long and 8 cm in diameter. The cervix was 17 cm in circumference and contained thick, clear mucus. The left ovary contained the corpus luteum of pregnancy. The left ovary was 4.5 x 2 cm and weighed 9.6 gm. The C.L. was 2 cm in diameter, yellow in color and compact. The right ovary was 3.5 x 2.5 cm and weighed 4.5 gm. It contained a follicle 1 cm in diameter filled with reddish, jelly-like material, a C.A. .5 cm in diameter and several small follicles. A complete list of standard morphometrics is retained in the author's files.

Two young male *Tursiops aduncus* were also captured by Ancol Oceanarium. The first one was captured on June 27, 1975, and until his death on July 26, 1975, he refused to eat fish and had to be tube fed. When he arrived he defecated, and the feces were green and somewhat solid.

One parasite, a trematode, was collected from the blowhole. However, he acted immature by continually emitting a dolphin distress whistle. He became friendly with his trainer until the pregnant female *Tursiops aduncus* mentioned above was put into the pool with him. From 20 minutes after she was put into the pool until she was taken from the pool critically ill, (a total of 12 days), he tried continually to nurse from this female. From the first day, the author had the impression that these two animals were acquainted and felt it was possible that the pregnant female was the young male's mother. The pregnant female would often nudge the male's genital area with her rostrum and the young male only left her side after he had become frustrated trying to nurse but receiving no milk. He would begin idly circling the pool emitting a distress call. Then he would lie on the bottom of the pool and give a forced exhalation of air which would billow to the surface. He would then hang vertically at the surface with his blowhole just above the surface, "crying" and turning slowly in circles. When he would not eat after all methods had failed, he had to be caught for tube feeding. This became increasingly more difficult because of pronounced aggressive behavior. He became quite adept at hitting his pursuers with his tail. Two days before the pregnant female was removed from the pool he began trying to mate with her. He had an erection and the author several times witnessed penetration of the male's penis into the female's vagina. The female was critically ill at this time and remained passive. When the female was removed he cried continuously for several hours and swam in various directions around the pool as if looking for her. During this time another young male was captured and put into the pool with the young male. The young resident male tried to nurse on him but was pushed away. A few days later this inappetent male died of *Pseudomonas pneumonia*. The new male ate well from the first day of capture but died later as a result of a traumatic pleurisy apparently obtained at the time of original capture. These two male *Tursiops aduncus* were very similar in size, and morphometrics are in appendix 4. In fact, the inappetent male was 177 cm in length while the male which ate well from first day of capture was only 170.5 cm in length. Table 2 shows the gonad sizes and weights.

TABLE 1: REPRODUCTIVE ORGAN WEIGHTS OF 1 MALE
AND 3 FEMALE *LAGENORHYNCHUS OBSCURUS*
FROM MARINELAND OF NEW ZEALAND.

DATE OF CAPTURE	DATE OF DEATH	LENGTH cm	WEIGHT kg	SEX	GONADS length-cm (weight-gm)		UTERUS HORNS	
					right	left	right	left
Accidentally drowned by fishermen	1974	130	32	male	7.0x1.0 8.0x1.0			
10/ 5/74	10/28/74	170	72	female*	5.0x2.0 (3.7)	4.5x1.5 (3.7)	12.0x2.0	11.0x2.0
5/ /72	2/ /74	170	61	female	3.0x1.0 3.0x1.0		12	12
9/23/73	10/23/73	130	30	female	Genital tract appeared immature			

*15 scars of *corpora albicantia* on left ovary
6 scars of *corpora albicantia* on right ovary

TABLE 2: REPRODUCTIVE ORGAN WEIGHTS OF 2
MALES FROM JAYA ANCOL OCEANARIUM.

DATE OF CAPTURE	DATE OF DEATH	LENGTH cm	WEIGHT kg	SEX	GONADS length-cm (weight-gm)	
					right	left
6/27/75	7/26/75	177	49	male	5.0x1.2 (6.0)	5.0x1.2 (4.9)
7/ 9/75	8/11/75	170.5	57	male	10.0x1.5 (13.0)	8.5x1.5 (12.5)

APPENDIX 1: MORPHOMETRICS OF FEMALE *LAGENORHYNCHUS OBSCURUS*
NEWBORN FOUND ON BEACH 17 SEPTEMBER 1974.

	cm
length, total.....	92.0
length, upper jaw to eye.....	15.7
length, upper jaw to melon.....	2.0
length of gape.....	12.8
length, upper jaw to external auditory meatus.....	19.4
center of eye to external auditory meatus.....	4.0
center of eye to angle of gape.....	3.5
center of eye to center of blowhole.....	9.5
eye to eye.....	12.4
length, upper jaw to blowhole.....	16.7
length, upper jaw to anterior flipper.....	25.0
length, upper jaw to tip of dorsal fin.....	25.9
length, upper jaw to umbilicus.....	49.5
length, upper jaw to midpoint of genital.....	65.5
length, upper jaw to anus.....	67.5
projection of lower jaw beyond upper jaw.....	0.5
girth, on a transverse plane intersecting axilla.....	54.5
girth, maximum.....	62.0
length, girth maximum to tip of upper jaw.....	44.0
girth, on a transverse plane intersecting the anus.....	33.0

Apertures: (cm)

dimensions of eye: height..... 0.5, length..... 1.5
length, mammary slits: right..... 0.8, left..... 0.8
length, genital slit: 4.8
dimensions of blowhole: width..... 0.5, length..... 2.0
diameter of external auditory meatus: pinpoint.

Appendages:

length, flipper (anterior insertion to tip).....	23.0
length, flipper (axilla to tip).....	16.0
width, flipper.....	6.8
height, dorsal fin.....	11.0
length, dorsal fin base.....	14.5
width, flukes.....	19.0
distance from anterior border to notch.....	10.0
depth of notch.....	0.5

Pressure lines: (from tip of upper jaw) 28.8 cm
38.1
52.3
59.4
44.6
64.8

APPENDIX 2: MORPHOMETRICS OF STILLBORN FETUS, *TURSIOPS*
ADUNCUS, 25 JULY 1975.

	cm
length, tip of upper jaw to notch.....	60.3
length, tip of upper jaw to center of eye.....	12.1
length, tip of upper jaw to apex of melon.....	4.0
length of gape.....	9.3
length, tip of upper jaw to external auditory meatus.....	14.4
center of eye to external auditory meatus.....	2.8
center of eye to angle of gape.....	2.8
eye to eye.....	9.0
length, tip of upper jaw to blowhole.....	11.4
length, tip of upper jaw to anterior insertion of flipper.....	17.6
length, tip of upper jaw to umbilicus.....	31.6
length, tip of upper jaw to midpoint of genital.....	40.3
length, tip of upper jaw to anus.....	41.8
projection of lower jaw beyond upper jaw.....	0.2
girth, on a transverse plane intersecting axilla.....	33.0
girth, maximum.....	34.5
length, girth maximum to tip of upper jaw.....	28.0
girth, on a transverse plane intersecting the anus.....	19.0

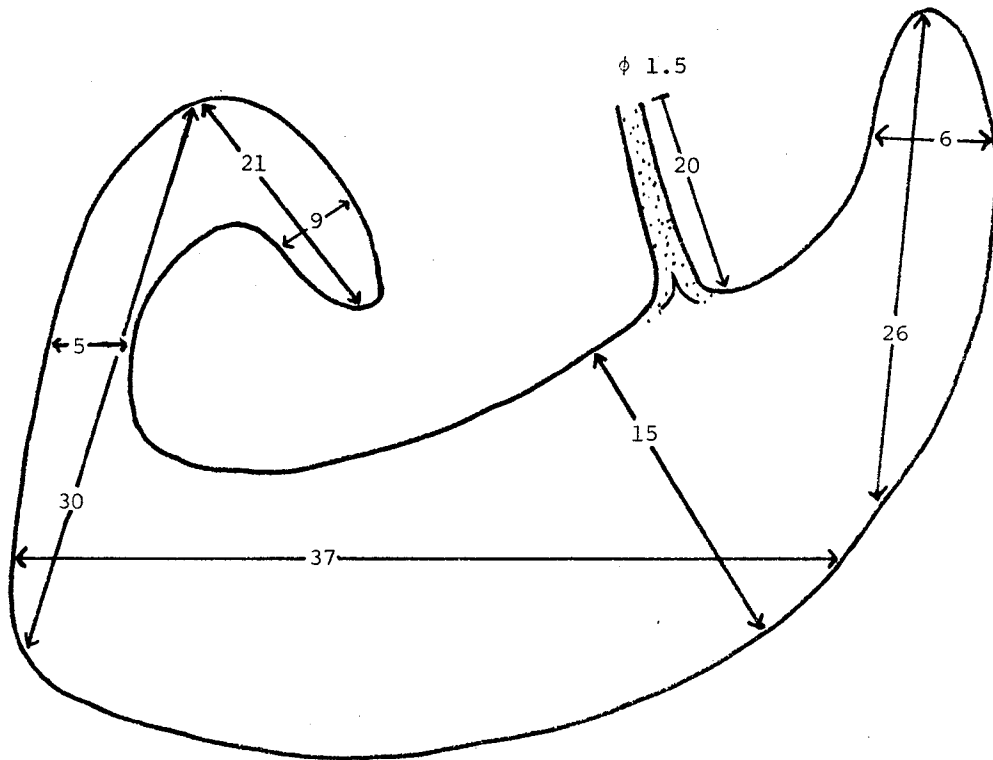
Apertures: (cm)

dimensions of eye: height..... 0.5, length..... 0.8
length, mammary slits: right..... 0.4, left..... 0.4
length, genital slit: 2.0
dimensions of blowhole: width..... 1.2, length..... 0.8
diameter of external auditory meatus: pinpoint

Appendages:

length, flipper (anterior insertion to tip).....	12.0
length, flipper (axilla to tip).....	9.0
width, flipper (maximum).....	4.5
height, dorsal fin.....	6.0
length, dorsal fin base.....	10.0
width, flukes.....	13.1
distance from nearest point on anterior border to notch.....	5.0
depth of notch.....	1.3

APPENDIX 3: MEASUREMENTS IN cm OF PLACENTA FROM *TURSIOPS*
ADUNCUS STILLBORN FEMALE CALF, 25 JULY 1975.



APPENDIX 4: MORPHOMETRICS OF TWO IMMATURE MALE *TURSIOPS*
ADUNCUS AT JAYA ANCOL OCEANARIUM.

	#1 cm	#2 cm
length, tip of upper jaw to notch.....	170.5...	177.0
length, tip of upper jaw to center of eye.....	29.5...	25.8
length, tip of upper jaw to melon.....	10.5...	11.0
length of gape.....	24.0...	22.5
length, tip of upper jaw to external auditory meatus.....	35.8...	32.2
center of eye to external auditory meatus.....	6.0...	6.3
center of eye to angle of gape.....	5.5...	5.0
center of eye to center of blowhole.....	14.0...	13.0
length, tip of upper jaw to blowhole.....	26.5...	29.4
length, tip of upper jaw to anterior insertion of flipper..	45.7...	42.0
length, tip of upper jaw to tip of dorsal fin.....	102.5...	106.0
length, tip of upper jaw to umbilicus.....	81.2...	86.0
length, tip of upper jaw to middle of genital.....	106.0...	107.0
length, tip of upper jaw to anus.....	120.7...	121.5
projection of lower jaw beyond upper jaw.....	0.8...	1.0
thickness of blubber, mid-dorsal.....	1.2...	1.0
thickness of blubber, mid-lateral.....	1.0...	0.5
thickness of blubber, mid-ventral.....	1.2...	0.8
girth, on a transverse plane intersecting axilla.....	91.5...	80.5
girth, maximum.....	98.0...	90.0
length, girth maximum to tip of upper jaw.....	77.5...	69.6
girth, on a transverse plane intersecting the anus.....	54.5...	46.5
Apertures:		
length, genital slit.....	9.0...	6.0
distance, genital slit from anus.....	9.0...	11.0
Appendages:		
length, flipper (anterior insertion to tip).....	31.0...	32.0
length, flipper (axilla to tip).....	23.0...	22.8
width, flipper.....	12.2...	12.1
height, dorsal fin.....	18.0...	16.5
length, dorsal fin base.....	24.8...	22.6
width, flukes.....	48.5...	46.0
distance from anterior border of flukes to notch.....	14.2...	12.6
depth of notch.....	3.5...	2.5

APPENDIX 5: ORGAN WEIGHTS OF TWO IMMATURE MALE
TURSIOPS ADUNCUS, AT JAYA ANCOL OCEANARIUM

	<u>gm</u>	<u>gm</u>
left kidney.....	160.0.....	199.0
right kidney.....	157.0.....	209.0
left adrenal.....	6.0.....	4.5
right adrenal.....	6.0.....	5.3
heart.....	235.5.....	258.0
liver.....	1.8 kg..	1.6 kg
spleen.....	35.8.....	33.0
pancreas (duct tortuous).....	110.0.....	96.0
brain.....	934.0.....	966.0
total weight.....	49 kg....	57 kg

APPENDIX 6

Miscellaneous reproductive information from the experiences of the author. The information was obtained while he was staff veterinarian at Naval Undersea Center, Hawaii laboratory.

Kogia breviceps

1. On April 25, 1974, Dr. Marta Lepés examined a 2.5 m female *Kogia breviceps* stranded with a small 1.7 m male on a beach outside Napier, New Zealand, Hawks' Bay. This animal had milk in her mammary glands and it is assumed the male was her calf. The male was estimated to be 7 months of age by Mr. Frank Robson, Napier. The female was also carrying a female fetus 30.8 cm long.

2. On July 20, 1974, a 2.6 m male *Kogia breviceps* stranded on a beach in Clifton, New Zealand (also on Hawks' Bay). The animal lived at Marineland of New Zealand for approximately one month before he succumbed to pneumonia. He was 275 kg in weight. His genital tract was examined. The vas deferentia had a diameter of 2 cm and were filled with a milky fluid. The vas deferentia were convoluted with mucosal folds and each filled an area 24 cm x 9 cm. The right testicle was 25 cm x 8 cm in size and weighed 1.4 kg. The left testicle was approximately the same size and weighed 1.1 kg. This animal was considered to be sexually mature and the fluid semen, although unfortunately no microscopic examination was made.

3. A baby *Kogia breviceps* was found by fishermen off Key Largo, Florida in May 1969. It was 95.3 cm long and weighed 15.4 kg. Slijper (1962) reported a length at birth of 1.0 meter. It was given to the author and taken to Dr. Jesse White of the Miami Seaquarium, where attempts were made to feed it. It began to take liquid food, but circumstances prevailed such that it had to be returned to the fishermen finders, and it soon died. Of interest are the feces from this animal, colored pink. This was considered normal because, on a diet of crustaceans, the mother's milk could have contained carotenoids.

Stenella longirostris

While working for the Naval Undersea Center in Hawaii, I was fortunate to be able to assist Sea Life Park and their veterinarian with treatment of their animals and in performing necropsies of our failures. The following table related reproductive information that I recorded during this time.

NAME (SEX)	DATE OF DEATH	LENGTH cm	WEIGHT kg	GONADS length-cm (weight-gm)		COMMENTS
				left	right	
Pukoo (female)	9/23/70	180	42			No follicles or C.A. Genital tract immature.
Alii (male)	4/ 8/71	180	50	7.4x1.5 φ(15)		Testicles inactive*
----- (male)	4/20/71	170	43			Testicles immature.
Pricilla (female)	3/28/72		47	2.0x1.2 2.1x0.7		Uterus: cervix 4.4, body 3.0 horns 9.0 length
Haole (male)	5/ 2/72	190	66	(330)	(310)	
Charlie (male)	5/12/72	180	50	(10)	(10)	

*Histological examination by Dr. Conklin.

2. I was also fortunate to receive from Dr. Nick Palumbo of the University of Hawaii, a neonatal *Stenella longirostris*. This animal was found swimming in the surf off Lanai Island, Hawaii and soon died. The animal was a female with a length of 89 cm. Harrison (1969) reports a length at birth for *Stenella* in Mexican waters of between 75-85 cm.

Stenella attenuata

I have only reproductive information from two *Stenella attenuata* which died at Sea Life Park. One, a 41 kg female named Mokunani, was 1.6 meters long when she died on April 7, 1971. The ovaries were 2 x 1 cm each and appeared grossly inactive. The genital tract appeared immature. A male, named Makamae was 1.8 meters long and weighed 68 kg when he died in March 1972. His left testicle weighed 8.5 gm.

Tursiops truncatus

Following are reports on various individual *Tursiops truncatus*. No discussion will be attempted concerning the data. It is included with the thought that it may be of use to other investigators.

1. Josie, a female *Tursiops truncatus* 2.5 meters long and weighing 183 kg, was captured in New Zealand on March 4, 1973, and died of pulmonary nocardiosis on September 26, 1974. The horns of the uterus were each 16 cm long with a diameter of 1.5 cm. The right ovary was 4.5 x 1.5 cm and contained a follicle 0.5 cm in diameter. The left ovary was 4.0 x 1.5 cm.

2. The following table provides reproductive information from various *Tursiops truncatus* which died in Hawaii.

NAME (SEX)	DATE OF DEATH	LENGTH cm	WEIGHT kg	GONADS length-cm (weight-gm)		COMMENTS
				left	right	
Surf (female)	4/26/71	230	110	C.L. of pregnancy		Miscarriage 3/8/71* Died of endometritis.
Bobbie (female)	8/23/71	220	94	2.5x1.0 2.5x1.0		No C.L., C.A. or follicles
Zelda (female)	11/9/71	220	98	3.0x1.5 3.0x1.2		Active ovaries with many follicles in all stages of maturation. Horns of uterus 21 cm long. Both have large follicles.
Garth (female)	2/17/72	240	82	5.0x1.5 1 C.A. 4.0x2.0 1 C.A.		
Peg (female)	6/10/72		116	2.0x2.0 1.5x1.0		
Niko (male)	11/22/72		115	12.7x7.6 (40) 12.7x7.6 (40)		Immature
Yellow (male)	12/4/72		70	(20)	(20)	Immature

*Miscarriage after conceiving in captivity. Placenta weighed 367 gm and was 50.5 cm x 25.5 cm in size. The umbilicus was 21.5 cm long and 3.2 cm in diameter.

Tursiops gilli

The following table contains reproductive information on Tursiops gilli from Hawaii.

NAME (SEX)	DATE OF DEATH	LENGTH cm	WEIGHT kg	GONADS length-cm (weight-gm)		COMMENTS
				left	right	
Noc (female)	Noc 3/26/70	200	78			Genital tract immature.
stranding (male)	8/17/70	270		25.4x7.6 25.4x7.6		
Pocle* (male)	10/30/75	270	225	8.0x2.0 8.0x2.0		Animal appeared old, but testicles appeared immature.
*Animal captured in Hawaii and transported to Indonesia where he died after one year at Jaya Ancol Oceanarium.						

Globicephala scammoni

The following table contains reproductive information on three
pilot whales; one female from Hawaii and two males from California.

NAME (SEX)	DATE OF DEATH	LENGTH cm	WEIGHT kg	GONADS length-cm (weight-gm)		COMMENTS
				left	right	
SLP #2 (female)	4/ 4/70			flat and wrinkled 5 cm in diameter C.L.		Aborted .6 m fetus morning of death.
Pip (male)	12/12/70	350	522	12.5x2.5* (50) 24.0x2.5 (85)		
Morgan (male)	2/21/73	400	709	21.5x4.3 (100) 20.0x4.0 (90)		Testosterone level 1/14/73 nil.

*May not be complete.

Orcinus orca

In Hawaii, Ahab, a male killer whale 5.2 meters long and weighing 2,130 kg died on September 27, 1972. His left testicle was 33 x 13 x 8 cm and weighed 3 kg. His right testicle was 32 x 10 x 8 cm and weighed 3.6 kg. He was thought to have been in rut during February 1972. Histological examination of his testicles showed them to be inactive.

Pseudorca crassidens

One false killer whale named Ola was autopsied by the author. This male was 3.3 m long and weighed 286 kg. He died on March 22, 1972, at Sea Life Park in Honolulu. His left testicle was 14 x 2 cm and weighed 100 gm. His right testicle was 14 x 2 cm also but weighed 140 gm.

Feresa attenuata

Three pygmy killer whales were autopsied by the author at Sea Life Park in Hawaii. One, a 2 m unnamed female weighing 100 kg died on December 20, 1971. Her genital tract was of juvenile appearance with no follicles, corpora albicantia or corpora lutea seen in the ovaries. The second arrival was an unnamed male 2.3 m long and weighing 129 kg. His right and left testicles were each 22 x 10 cm in size when he died on December 29, 1970. The third and unnamed male weighed 182 kg. The morphometrics are in the files of Sea Life Park. When he died on August 27, 1971, his testes appeared mature and active. Subsequent histological examination showed them to be active, with sperm in the tubules. There was also sperm in the lumen of the vas deferentia.

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DOLPHIN REPRODUCTION IN WESTERN EUROPE

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INTRODUCTION

In 1964 in Morecambe, England, and in 1965 on the continent the first dolphinariums started to operate. In the spring of 1965 an American road show started to operate in Europe as well, quickly leading to some 20-30 small operations (pool diameter ca 10 m). Over 95% of the European dolphinariums have a closed circuit water system, with make-up water using NaCl exclusively. A few use seawater: Marineland S.A., Mallorca and Marineland, Morecambe, England. The Dolfinarium, Harderwijk, which also operates a dolphinarium at Brügge, Belgium and a third in the Münster Zoo, West Germany, uses an artificial make-up which comes close to artificial seawater as used in aquariums (Dudok van Heel, 1975).

BIRTHS

Through personal communication with curators, managers and veterinarians I learned about quite a number of births. Many of them were premature or still-births or the calves died soon. By far the majority of these happened during or not long after transport from the U.S.A. Only the skill of an attending specialized veterinarian is able to save the mother during transport.

A few dolphins have been born alive, the mothers having conceived in the wild and been transported at an early stage in pregnancy. On April 27, 1971, the Barcelona Zoo imported four dolphins. A calf was born in November which died after four days (Caldes, 1972).

A second case concerns a birth at Marineland, Mallorca. The infant was born in December 1974 and lived for 70 days. Post mortem revealed, apart from infection, a number of parasites. It should be recalled that

Marineland uses natural seawater. A report is being prepared for publication in "Aquatic Mammals".

At Harderwijk a number of dolphins have been imported to establish a breeding group (Dudok van Heel and Meyer, 1974). Since 1971 8 infants have been born. A report has been published on nos. 1 and 2 (Dudok van Heel and Meyer, 1974). Two more reports are under preparation and will also be published in "Aquatic Mammals". All eight calves were conceived in captivity.

Infant no. 3 was delivered, luckily prematurely, by a sick dolphin who was too weak for pregnancy. After the abortus we were able to save the dam. All others were born normally and alive. We have experienced no stillbirths. Nos. 4 and 5 lived for a week, no. 7 for 6 weeks. The death of no. 5, among other factors, lead to changes in the composition of the water (Dudok van Heel, 1975).

Nos. 6 and 8 are still alive at the conclusion of this paper, January 6, 1976. The elder was born in August, 1974, the younger in August, 1975. The elder one is still nursing and does not take more than 1-2 kg of fish per day, often less or even skipping solid food altogether.

In the night of July 29/30, 1975 a dolphin was born in the Dolphin-arium at Rapperswill, Switzerland. Conception also took place in captivity. At this moment the infant is growing up well.

CONSIDERATIONS

In my earlier paper (Dudok van Heel and Meyer, 1974) I postulated that a pool should have a minimum size of diameter 12 m for a circular pool and ca 15 x 10 m for a rectangular pool. Calf no. 6 in Harderwijk was born in a pool of ca 11 m diameter and 4 m depth, to a very observant dam, who did not panic. She more or less followed the calf and did not show the more aggressive behaviour, observed and described (Dudok van Heel and Meyer, 1974). Calf no. 8 was born in a pool of 21 x 8 m, and 2.6 m water depth. The width tended to be on the narrow side as the cow could not prevent the calf from bumping a few times into the glass window front. It is interesting to note that the irregular shaped pool at Rapperswill is about 10 x 15 m, with a depth of water of 3.5 m. In

my opinion, an oblong pool is to be preferred to a circular pool. In a circular pool the mother has to correct her course continually and in the first 24-48 hours, judging from the behaviour of the infant, this is stressing to some extent. The larger the pool the better, as it is easier to build up and maintain higher speeds. In the first month a dolphin calf cannot remain still and gets nervous when it has to do so. On the other hand when the cow keeps a fair speed the little one is bowriding along her side, does not need to swim except when surfacing to blow, and therefore can sleep, a very important behaviour in any infant.

In my opinion aunts are not required and may even be a nuisance (Dudok van Heel and Meyer, 1974). The cow is able to deliver the calf herself and a normal infant is completely capable of surfacing alone for its first breath.

Most probably parturition in aquatic mammals delivering underwater is fast. In Harderwijk we have one very well documented case of a normal birth within four minutes. This was the case in an old female. In a young female having her first calf the parturition was witnessed completely and lasted one hour. Two others which were not observed could, however, be pinned down to have lasted 1-1 1/2 hours at most. In my opinion long lasting parturitions are abnormal and may be one of the causes for the high mortality in dolphin infants and most surely of stillbirths at full term. Both problems - aunts and stillbirths - are dealt with in a separate paper, which still is under preparation and will appear in "Aquatic Mammals".

It is only relatively recently that births started to occur in Europe. The main reason is - apart from proper husbandry - that most establishments imported animals too young for reproduction but which are supposed to be better for training. As a female has to be at least in her 6th year and a male 12-14 years old before mating is successful, one has to wait and keep his animals alive. Harderwijk imported an old bull and a number of old females around 1970-1971 for the very purpose of breeding, and it is not surprising, therefore, that the first results became evident here. Rapperswill has followed and I have no doubt that this healthy trend will spread.

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OBSERVATIONS ON THE SEXUAL BEHAVIOR OF INDIAN OCEAN
BOTTLENOSED DOLPHINS (*TURSIOPS ADUNCUS*)

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INTRODUCTION

Sexual behavior is a prominent feature of the activities of captive bottlenosed dolphins, and groups of dolphins of all age and sex classes may simultaneously participate in protracted and vigorous courtship-like behavior. Oppositely sexed partners frequently suspend copulatory activity or courtship displays to engage in homosexual interactions which closely resemble heterosexual mating sequences. In the Indian Ocean bottlenosed dolphin (*Tursiops aduncus*) the behavioral roles and postures characteristic of courtship are interchangeable between the sexes so that the bull or the cow of a consorting pair may alternately adopt the active or the passive role and either partner may display similar initiating postures in mating contexts (Saayman, Tayler and Bower, 1973). Moreover, dolphins of either sex are reported to engage frequently in autoerotic activities (McBride and Hebb, 1948; McBride and Kritzler, 1951; Tavolga, 1966; Caldwell and Caldwell, 1972). Whereas it is well recognized that captive conditions may elicit atypical behavior in many terrestrial mammals - and we have therefore provided our captive dolphins with the most spacious facilities within our means (Tayler and Saayman, 1973a) - the high rates of copulatory activity observed in free-swimming dolphins (Saayman, Tayler and Bower, 1973) suggest that high levels of sexual behavior are characteristic of the normal social interactions of these marine mammals.

Descriptions of precopulatory and mating behavior are available for the Atlantic bottlenosed dolphin, *Tursiops truncatus*, (Tavolga and Essapian, 1957) and for the Indian Ocean bottlenosed dolphin (Saayman, Tayler and Bower, 1973). However, very little is known of the physiological

events associated with ovulation in these cetaceans, although a number of observers have suggested that a restricted mating season occurs in *Tursiops truncatus* (McBride and Hebb, 1948; Tavorlga, 1966; Ridgway, 1972). Whereas Evans and Bastian (1969) have noted an apparent seasonality of sexual behavior in free-swimming delphinid populations, they comment, in contrast to the above workers, that "...observations of captive populations indicate high levels of sexuality throughout the year" and that "captive delphinids (*Tursiops* and *Lagenorhynchus*) regardless of age, sex, or time of year, do indeed display sexual activities that are quantitatively and qualitatively quite impressive" (p. 454).

Observations of captive and free-swimming *Tursiops aduncus* indicate that copulatory activity occurs throughout the year in this species, although a peak of mating activity may occur in the spring and early summer. We have speculated elsewhere that ovulation is restricted to this period of heightened sexual activity and that it is induced by the coital stimulus (Tayler and Saayman, 1972). This hypothesis is elaborated in the present report and further observations on reproductive behavior in *Tursiops aduncus* are presented.

METHODS

Captive Dolphins

Observations were made on two mature Indian Ocean bottlenosed dolphin cows (*Tursiops aduncus*) in the circular Main Tank (capacity 820,800 liters) of the Port Elizabeth Oceanarium for four years (1963-1966) during which time no dolphin bulls were present. Two mature bull bottlenosed dolphins were introduced to the cows in the Main Tank in November 1967.

The dolphins were transferred to a large Dolphin Pool (capacity 4,742,400 liters) in November 1968. Quantitative records of the social behavior of an adult bull, an adult cow and their two year old female calf were obtained between March 1970 and February 1971, during which time observation sessions 30 minutes in duration were conducted five days per week. Quantitative data on captive dolphins in this report were derived from 90.5 hours of observation made at midday and in the early

afternoon - a time when social interactions were most frequent (Saayman, Tayler and Bower, 1973). At 1100 and 1530 hours the dolphins took part in daily public displays, 30 minutes in duration, when they were fed to capacity. Comprehensive accounts of the conditions under which the dolphins were maintained have been presented elsewhere (Tayler and Saayman, 1972; Tayler and Saayman, 1973a).

Free-Swimming Dolphins

Systematic scoring of the behavior of free-swimming dolphins commenced in January 1970. Binoculars (8 x 35 and 20 x 60) were used during all observation sessions. Dolphins were observed in two areas along the south-eastern Cape coast: Algoa Bay (34°S 25°E), and Plettenberg Bay (34°S 23°E). A dawn to dusk watch was systematically maintained for dolphins in the Plettenberg Bay study area during routine seasonal field expeditions conducted between October 1970 and July 1973. Quantitative data presented in this report on free-swimming dolphins are based upon 119 sightings of bottlenosed dolphins, incorporating 103 hours of direct observation of the animals. Detailed accounts of the conditions of observation and scoring methods have been presented elsewhere (Saayman, Bower and Tayler, 1972; Saayman, Tayler and Bower, 1973).

RESULTS

Behavior of Captive Cows in the Absence of Bulls

Whereas it is well recognized that unsatisfactory captive conditions may induce abnormal behavioral syndromes in many animals, the two bottlenosed dolphin cows exhibited only mildly adverse responses to captivity. These included the ingestion of foreign objects, gastrointestinal disorders and periodic inappetence, which we have attributed elsewhere to the incorrect design of the small circular tank (diameter 21.5 m) in which the dolphins were originally maintained and to the effects of occasional chemical treatment of the water (Tayler and Saayman, 1973a). However, a dramatic behavioral change occurred each year in spring, commencing with mild behavioral aberrations which increased to reach a peak of violent agitation when severe self-inflicted injuries were incurred.

A deterioration in the quality of the dolphin public performances provided an outstanding index of the onset and duration of this period.

The dolphins became unpredictable and did not adhere to the normal standards: On occasions the animals refused to participate or else they overplayed their roles, for example, by leaping to excessive heights to receive a fish, much to the consternation of the handler. A temperamental change was thus detectable by the handler well before any other atypical behavior became apparent.

A number of abnormal behaviors were characteristically seen: (a) The dolphin lay motionless on the surface for some minutes, then, turning on her side, beat the flukes violently and, with only partial propulsion, sometimes collided with the sides of the tank. (b) The dolphin swam at high speed around the perimeter of the tank and on occasions barely avoided a catastrophic collision with the viewing port at which the observer was situated. (c) The dolphin leaped clear of the water, usually avoiding violent contact with the wall whilst airborne (Figure 1). (d) The dolphin occasionally collided violently by hurling itself sideways against the wall (Figures 2 and 3). This behavior resulted in abrasions and lacerations of the torso, extremities of the flippers, flukes and dorsal fin. On one occasion a large area of skin was stripped from the flank and, as seen from the underwater viewing port, the dolphin was momentarily enveloped in a cloud of blood. (e) The dolphin violently jerked its head up and down or from left to right whilst airborne (Figure 4), sometimes opening and closing its mouth. On one such occasion the tip of the rostrum was knocked off, exposing the mandible. (f) The above episodes were interspersed with periods of quiet when the dolphin lay motionless on the bottom of the tank for abnormally long periods or else swam slowly in small circles with the eyes closed. (g) Food consumption was dramatically reduced in both animals and the older cow once refused to eat for a full week. The loss of appetite was far in excess of that induced by periodic chemical treatment of the water or stress due to confinement in a small tank. (h) There was a general decline and sometimes a complete absence of the playful activity which normally characterized the social relationships of the dolphins either with each other or with other species (seabirds, fish, turtles) maintained in the same tank. In the spring of 1965 social interaction between

the two animals were completely curtailed and there was a dramatic decrease in the frequency of whistle phonation. The later effect persisted for several months even after normal relationships between the dolphins had been re-established.

The above behavioral syndrome occurred for the four successive years prior to the introduction of bulls to the two cows. Symptoms became apparent each year in spring but commenced approximately two weeks later with each successive year in both cows. The two animals, however, differed in the following respects: (a) The onset of symptoms did not coincide in the two animals and behavioral changes in the younger cow always preceded those in the older cow. (b) Symptoms were displayed for progressively longer periods each year in the younger cow with a maximum duration of four months. In the older dolphin the duration remained relatively constant at approximately six weeks. (c) The younger cow displayed more severe symptoms and this animal alone incurred self-inflicted injuries. The older cow became highly aggressive and exerted her dominance over the younger dolphin more than was usual. With respect to the handler, she became withdrawn and listless and, when accepting food or returning apparatus, she immediately withdrew and refused to be touched.

Behavior of Captive Cows following the Introduction of Bulls

Two mature bottlenosed dolphin bulls were netted in the sea and immediately introduced to the two cows in November (Spring) 1967, the fifth year of dolphin maintenance. Copulation commenced within hours of the introduction of the bulls. The temperament of both cows changed dramatically and all abnormal behavior ceased and has not recurred in the subsequent six years, during which time both sexes have been maintained together. It was noteworthy that only the older cow became pregnant, whereas the younger cow, despite daily copulation, fell pregnant only in the following spring.

Courtship behavior was subsequently seen to be an almost daily feature of the diurnal activities of the captive dolphins and occurred irrespective of the time of the year. A quantitative study of the courtship behavior of an adult bull, an adult cow and their two year old female

calf, conducted when the dolphins had been transferred to the large Dolphin Pool, failed to detect any significant variation of courtship-like behavior in relation to season, although there were highly significant seasonal variations in the environmental variables measured (Table 1). It should be noted that the cow was lactating throughout the course of the quantitative observations and that she became pregnant only some ten months later (see below).

However, the dolphin handler (C.K.T.) continued to detect a change in the temperament of both the bulls and the cows each year in spring and in early summer, at which time there appeared to be an increase in the intensity of sexual interactions. Moreover, public performances became discontinuous at this time of the year and were frequently disrupted by periodic mating behavior, sometimes to the embarrassment of the institution.

Birth Interval

Four births have occurred in the Oceanarium (Figures 5,6, and 7). Two calves, delivered by the older cow, were both born in December: the first, a female, born on December 12, 1968, and the second, a male, born on December 30, 1972. Both of these calves have survived and have developed as healthy, active, well-integrated members of the dolphin colony. Births occurred earlier in the year in the case of the younger cow: the first, a male (weight 12 kg, length 112 cm) which died shortly after birth in October 1969, after a very long delivery, and the second, a female which, judging by the weight and size (weight 7 kg, length 76 cm) was born prematurely on October 26, 1970, after the mother had been severely ill for several months. The mother died subsequently on November 25, 1970, and a postmortem revealed that she had only one functional lung: the other had atrophied to a tough mass of tissue attached to the chest cavity.

Copulation occurred during both pregnancies in the older cow, but was terminated some eight weeks prior to parturition. Similar behavior was noted during the first pregnancy of the younger cow, but as she became progressively ill during her second pregnancy, she withdrew from the group and became increasingly inactive in every respect.

Lactation in the older cow continued into the second pregnancy and milk was last seen in the mouth of the calf in February 1971, when she was three years and two months of age. This calf had commenced to take solid fish at the age of six months, but evidence for continued suckling was derived from observations of a habit the young dolphin had acquired of releasing milk from her mouth in the presence of observers at the underwater viewing port, apparently in order to attract attention (Tayler and Saayman, 1973b).

Observations on Free-Swimming Dolphins

Data on the occurrence or non-occurrence of courtship behavior patterns in 119 groups of free-swimming bottlenosed dolphins were obtained during 103 hours of direct observation of the animals between October 1970 and July 1973 and were analysed in relation to season of the year (Table 2). Whereas courtship behavior was observed in 30.8% of the sightings obtained in the spring and 15.0% of the groups observed in the winter, these differences were not statistically significant ($\chi^2 = 1.93$, df 3; $p < 0.7$).

DISCUSSION

The evidence presented in this report, though largely anecdotal and limited to a small sample of animals, suggests that courtship and sexual activity in *Tursiops aduncus* is not restricted to clearly defined periods of "estrus" comparable to those seasonally breeding mammals which display abruptly initiated and terminated periods of "heat" associated with characteristic changes in the ovaries and genital tract (Eckstein and Zuckerman, 1956). Copulation apparently occurs throughout the year in this species, both in captivity and under naturalistic conditions, and pregnant and lactating cows show the full pattern of copulatory behavior. It would seem, then, that sexual activity in *Tursiops aduncus* is at least partially independent of hormonal control and we have speculated elsewhere (Tayler and Saayman, 1973a; Saayman and Tayler, 1973; Saayman and Tayler, in press) that courtship-like behavior may function in a "greetings" context to reinforce social bonds in those delphinid species which display "non-cohesive" or "extensible" social systems.

Nevertheless, the onset each year in spring of the unusual behavioral syndrome in two cows maintained without bulls, together with qualitative observations of seasonal increases in mating behavior following the introduction of bulls, suggested that an increase in levels of gonadal hormones coincides with increased water temperature and daylight length in spring, giving rise to a period of heightened sexual receptivity and attractiveness. Moreover, the dramatic cessation of the abnormal behavioral syndrome in the older cow following the introduction of bulls, and her subsequent fertilization, suggested that the hormonal and physiological conditions for ovulation were favourable in this animal, whereas the prior decrease in abnormal behavioral symptoms in the younger cow indicated that she had already become anestrus. Furthermore, the persistence of the abnormal behavioral patterns of the two cows in the absence of bulls in spring and the dramatic cessation of these symptoms in the older cow immediately subsequent to copulation suggested that ovulation was induced by the coital stimulus: these observations are reminiscent of the persistence of estrous behavior in animals such as the rabbit and the ferret, in which ovulation is known to be dependent upon copulation since, "Oestrous persistis until copulation and ovulation have occurred in such animals" (Brambell, 1956, p. 460). In the rabbit, for example, the doe may remain in heat for up to 36 days in the absence of the buck (Hammond, 1925, quoted by Eckstein and Zukerman, 1956, p. 258). Our behavioral data, then, provide some support for the histological evidence of Harrison et al (1972) who write: "Ovarian appearances seem to suggest that captive *Tursiops* exhibits induced ovulation and that there is little evidence of cyclic infertile ovulations" (p. 388).

Evidence derived from captive births, given a gestation period of 12 months, indicates that conception occurs during the spring and early summer. It is noteworthy that the onset of the abnormal behavioral syndrome in the younger cow always preceded that of the older cow and that the younger cow gave birth in spring (October), whereas the older cow gave birth in summer (December), further indicating that the aberrant behavior in captive conditions was, indeed, associated with a seasonal increase in ovarian activity.

These findings suggest a periodicity of breeding in *Tursiops aduncus*, which ensures that parturition coincides with warm water temperatures and the abundance of food, conditions favoring the survival of the calves. Although evidence derived from sightings of free-swimming populations of bottlenosed dolphins is merely suggestive due to difficulties which are often encountered in estimating the ages of animals in large and compact, fast-moving schools, it is our impression that, in the majority of cases, young calves are present during the spring and summer months. The majority of records of freshly stranded, newborn bottlenosed dolphin calves have been collected along our coasts between October and March, with only one record in the winter month of June (G.J.B. Ross, Port Elizabeth Museum, personal communication). It, therefore, seems likely that births may be distributed throughout the year in free-swimming groups of bottlenosed dolphins and that a birth peak, as opposed to a clearly circumscribed birth season, is characteristic of these animals. Similar findings for another inshore dolphin (*Sousa* sp.) in eastern Cape waters are described elsewhere (Saayman and Tayler, in press).

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TABLE 1: FREQUENCIES OF COURTSHIP BEHAVIOR PATTERNS IN THREE CAPTIVE BOTTLENOSED DOLPHINS (A BULL, A COW AND THEIR CALF) IN RELATION TO SEASONAL VARIATIONS IN CLIMATIC FACTORS. (MEAN VALUES PER OBSERVATION PERIOD \pm S.E.).

	SPRING (Sept-Nov)	SUMMER (Dec-Feb)	AUTUMN (Mar-May)	WINTER (June-Aug)	F RATIO	df	P
Mean No. of Courtship Behaviors	27.2 \pm 4.8	33.0 \pm 5.5	31.5 \pm 6.2	43.0 \pm 5.6	1.71	3,177	<0.25
Mean Water Temperature ($^{\circ}$ C)	17.8 \pm 0.4	20.5 \pm 0.5	17.8 \pm 0.3	15.8 \pm 0.2	68.8	3,177	<0.01
Mean Air Temperature ($^{\circ}$ C)	19.3 \pm 0.4	22.1 \pm 0.4	20.4 \pm 0.5	18.5 \pm 0.5	10.4	3,177	<0.01
Mean Humidity Saturation (%)	65.8 \pm 1.3	64.3 \pm 2.1	66.3 \pm 2.6	52.6 \pm 2.8	8.9	3,177	<0.01
Mean Atmospheric Pressure (millibars)	15.9 \pm 0.8	12.2 \pm 0.8	18.8 \pm 0.8	19.2 \pm 0.9	11.4	3,177	<0.01
Mean Wind Force (m.p.h.)	14.0 \pm 1.1	19.1 \pm 1.5	13.3 \pm 1.4	11.9 \pm 1.2	5.1	3,177	<0.01
No. of Observation Sessions	55	52	26	48			

TABLE 2: THE OCCURRENCE OF COURTSHIP BEHAVIOR PATTERNS IN GROUPS OF FREE-SWIMMING BOTTLENOSED DOLPHINS IN RELATION TO SEASON (OBSERVED AND EXPECTED FREQUENCIES) (119 SIGHTINGS).

	NUMBER OF SIGHTINGS OF DOLPHIN SCHOOLS			$\bar{X} \pm$ S.E. DURATION OF OBSERVATIONS/ SIGHTINGS (mins)
	+	-	%	
Spring (Sept-Nov)	12 9.5	27 29.5	30.8	43.9 \pm 8.2
Summer (Dec-Feb)	5 5.6	18 17.4	21.7	64.0 \pm 11.2
Autumn (March-May)	9 9.0	28 28.0	24.3	58.4 \pm 13.8
Winter (June-Aug)	3 4.9	17 15.1	15.0	51.8 \pm 17.8

+ = Courtship behavior occurred

- = Courtship behavior did not occur

% = Percentage of sightings with courtship interactions



1



2



3



4

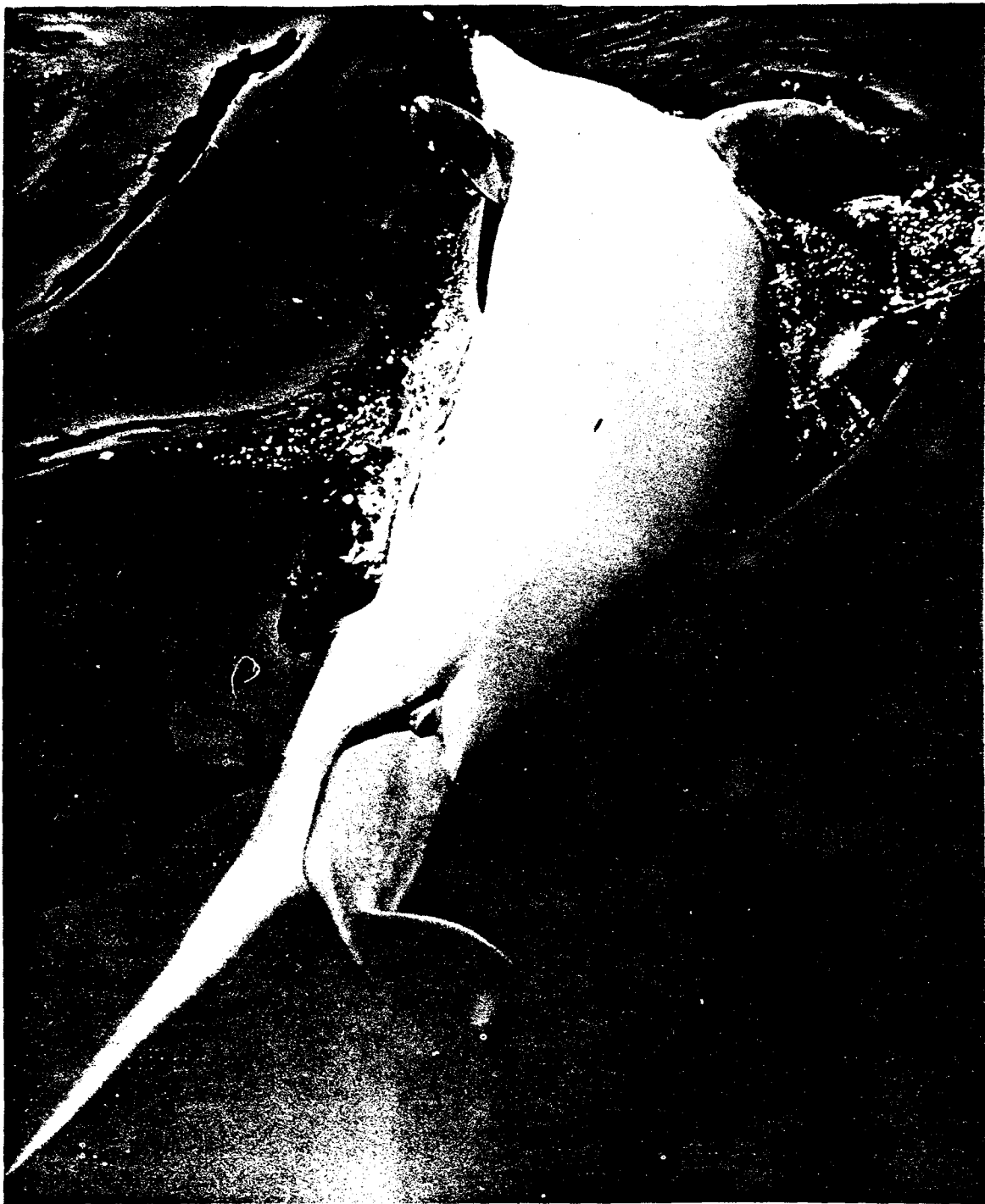


Figure 5



Figure 6



Figure 7

DOLPHINS AND OTHER CETACEANS
IN JAPANESE AQUARIUMS

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There are over sixty aquariums in Japan, of which about half have exhibited cetaceans over the years since 1928 when the Nakanoshima Aquarium exhibited a minke whale (*Baleaniptera acutorostrata*) and some bottlenosed dolphins. Hanshin Zoo for several months in 1937 exhibited a dozen pilot whales.

Today one collection regularly breeds cetaceans in Japan, namely Enoshima Marineland located on the inland sea near Fujisawa. No less than 22 bottlenosed dolphins (*Tursiops gilli*) have been born at this facility; one female alone has had at least eight young, and perhaps more. Three other cetacean species also have bred here, most with poor success. Bottlenosed dolphins have been born in 1962, 1966, 1968, 1970, 1972, 1973, 1974 and in 1975, almost all in the spring of the year (April-May), and all have been conceived in captivity. All of the young born in 1974 were stillbirths. In the fall of 1975 the young from 1972, 1973 and 1975 were still alive.

At Enoshima all species are kept in one very large rectangular pool which is about the size of the new killer whale pool at San Diego Sea World. This is further subdivided into a series of irregularly shaped segments by means of heavy nets which can be shifted by aquarium personnel. I believe this is an open system.

A problem in determining just what has been done in the past and is now being carried on in Japan is that of language differences. Most of the publications are in Japanese characters, making translation difficult. Directors and staff of the various Japanese aquaria rarely read or have the ability to write English, and thus letters may not be replied to. Much as with private oceanaria in the U.S., far too little has been

published to date. However, at the Tulsa Zoological Park, Tulsa, Oklahoma, the General Curator, Mr. Ken Kawata, is of Japanese ancestry and has provided me with invaluable assistance since 1969, and I am sure would be willing to help anyone at this meeting desiring to make contact with counterparts in Japan. He has made a translation of an article that appeared in the magazine Animals and Zoo in July 1968 by Dr. Nakajima of Enoshima on what species of cetaceans had been exhibited and years of exhibition in Japanese aquaria. This list was updated to 1969 by Ken and Dr. Nakajima. It is shown in Table I. The article is as follows:

DOLPHINS AS DISPLAY ANIMALS IN JAPAN

Dr. Masayuki Nakajima
Curator, Enoshima Marineland

The oldest record of dolphins being kept in Japan is around 1928 at the Mito Aquarium, where a minke whale and bottlenosed dolphins were kept.

In 1935, a Blackfish (pilot whale) was put on temporary display at the Yokohama Fair and drew great popular interest. In 1937, the Hanshin Park succeeded in keeping 10 false killer whales for 8 months. As of today, there are 21 places where dolphins have been or are being kept in Japan (see Table I).

In Japan the dolphins are usually fed mackerel and squid. In 11 years at the Enoshima Marineland, 25 babies (3 Risso's dolphins, 22 bottlenosed dolphins) have been born.

TABLE I: SPECIES OF DOLPHINS AND WHALES CURRENTLY (A) AND FORMERLY (X) HELD AS DISPLAY ANIMALS IN JAPAN.*

ESTABLISHED	AQUARIA	CITY	SPECIES															
			Balaenoptera acutorostrata	Kogia breviceps	Globicephala macrorhyncha	Pseudorca crassidens	Feresa attenuata	Peponocephala electra	Grampus griseus	Tursiops gilli	Lagenorhynchus obliquidens	Delphinus delphis	Stenella caeruleo-alba	Stenella attenuata	Steno bredanensis	Phocaena phocaena	Neophocaena phocaenoides	
'28	Mito	Numazu	X						X	A	X		X		X			
'37	Hanshin Park	Nishinomiya			X													
'54	Yatsu Yuen	Narashino								X								
'56	Atami	Atami								X								
'57	Enoshima	Fujisawa			X			X	A	A	X	X	X	X	X			
'57	Shimonoseki	Shimonoseki				A			X	A	X						X	
'57	Misaki	Osaka								X		X						
'57	Takeshima	Gamagori			X					X				X	X		X	
'58	Ito	Ito					X		X	A	X	X	X	X	X			
'58	Saikaibashi	Sasebo								X	X	X						
'58	Ohotsuku	Abashiri														X		
'58	Naruto	Tokushima															X	
'59	Toba	Toba							X	A	X						A	
'60	Irukajima Yuenchi	Toba							X	A								
'60	Miyajima	Hiroshima								X							X	
'61	Ujina	Hiroshima															A	
'63	Awashima Kaiyo Koen	Numazu						X		A								
'64	Yase Leisure Center	Kyoto															X	
'67	Akashi Marine Park	Akashi								A								
'67	Shimoda	Shimoda			X								X		X			
'68	Terushima Land	Iwaki							A	X	A							
'68	Nagasaki	Nagasaki															X	
'68	Bentenjima	Shizuoka		X														
'69	Echizen Matsushima	Fuki									A							

*Reprinted from *Animals and Zoos*, Vol. 20, No. 7, 1968, with additions by the author, Dr. Masayuki Nakajima, Curator, Enoshima Marineland, Japan.

SOCIAL INTERACTIONS AND REPRODUCTION
IN THE ATLANTIC BOTTLENOSED DOLPHIN

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INTRODUCTION

The establishment of breeding colonies of dolphins has always been a worthwhile objective. It is a particularly appropriate goal to strive for today as public pressures mount against the capture of wild animals, even those that are not considered endangered.

Social structure is certainly one of the many factors that has to be considered in putting together a successful breeding colony. In highly social animals such as Atlantic bottlenosed dolphins (*Tursiops truncatus*) it is particularly important.

Some aspects of dolphin behavior have contributed to the ease with which successful breeding occurs in captivity in these animals. The species has exhibited no particular environmental requirements for successful copulation that are not met even in relatively small holding tanks. The copulatory drive is also exceptionally high. Whereas we know little about their reproductive physiology, conception can apparently take place year round, with peak mating periods probably varying with locality (see Caldwell and Caldwell, 1972). The highly-developed protective instinct of the females toward not only their own infants but those of other mothers as well has undoubtedly increased the probability for successful rearing (see, e.g., Tavolga and Essapian, 1975; Caldwell and Caldwell, 1966). Conversely, several factors related to social behavior have had negative effects on both breeding and rearing of the young in captivity. These problems are largely related to aggression, chiefly by mature bulls.

BREEDING

Mating

We should first make it clear that the use of the word mating implies that we know more about the subject than is true. Dolphins engage in so much sexual activity that could not result in conception that the identification of true breeding behavior is not as simple as it may sound. The reproductively non-functional activities in captive dolphins have been described in many papers, beginning with those of McBride and Hebb (1948) and McBride and Kritzler (1951). These include self-stimulation and homosexuality which of course leave no doubt in the observer's mind that conception could not occur. However, as animals of both sexes and all sizes and stages of sexual maturity copulate or attempt to copulate with each other, the individual wishing to identify reproductively meaningful behavior is left in a somewhat confused state.

Tavolga and Essapian (1975) have described sexual behavior in a stable breeding colony at Marineland of Florida. Their observations extended over a three-year period and extended the earlier observations of McBride (1940), McBride and Hebb (1948) and McBride and Kritzler (1951). The major exception that we have to find with the description of Tavolga and Essapian (1957) of mating behavior is that we attach major importance to the more aggressive components, one of which they did not mention. This is the violent head to head encounter after a high-speed approach (see Caldwell and Caldwell, 1967, 1968). Norris and Prescott (1961) also observed this behavior in a precopulatory context in the pilot whale (*Globicephala scammoni*). Our observations were made in the early mornings at Marineland of the Pacific before the public was admitted, and although we have not seen this ourselves at Marineland of Florida, a recent quantitative study done at this facility on sexual behavior of a pair of bottlenosed dolphins showed that this "head butting" was the single index of the several indices of sexual behavior used that was inevitably followed by copulation (Puente and Dewsbury, 1976). That study was also done in the early morning hours before the public was admitted and employee activity is reduced. It would appear then that much true mating behavior is either inhibited by external activity or is conducted at night or in the early morning or late hours. Such seemingly violent aggressive

behavior is an integral part of precopulatory activity in many mature mammals and it is not unknown in our own species. Precopulatory fighting is distinguishable from true fighting by the pattern of each individual's returning to the other, rather than leaving and the lighter (or lack of any) tooth marks inflicted. Leaping clear of the water in the approach is also frequent.

The posturing illustrated in the Tavalga and Essapian (1957) paper has probably been given more emphasis than the authors intended. We have seen very little of it and the context may or may not be sexual. The illustration itself has doubtless caught the reader's eye although the authors assigned it a subordinate role in precopulatory behavior.

No vaginal swabs to determine the presence of viable sperm have been reported. The only incidence of apparent ejaculation is included in the Tavalga and Essapian (1957) paper.

Sexual Maturity

The age of sexual maturity is still controversial. The case of the female Spray, born at Marineland of Florida, who gave birth at seven years of age (Tavalga and Essapian, 1957) seemed to establish the onset of sexual maturity in females as age six. More recent data from animals from this same region (northeastern Florida) indicate that 12 years may be more typical of females and 13 for males (Sergeant, Caldwell and Caldwell, 1973). Whatever the cause for the early onset of sexual maturity in Spray, the absence of normal maternal behavior in this animal at age seven suggests that she was not prepared for motherhood, perhaps attributable to hormonal deficiency. Spray did exhibit normal maternal behavior toward the infants which she bore in later years. At any rate, at least in northeastern Florida, we would feel more secure in beginning a breeding colony with females minimally 235 cm in standard length (tip of upper jaw to fluke notch in a straight line) and males approaching 245 cm in standard length (also see Caldwell and Caldwell, 1972).

We have not processed our data on northeastern Gulf of Mexico animals as yet, but they may be slightly shorter at sexual maturity. We have no material on animals from southern Florida, but perhaps such data are available from the Miami Seaquarium.

Hopefully some of the later speakers will have more data to add about oestrus periods and testosterone levels, both of which need more work of the type initiated by Ridgway (1972) on the latter.

Seasonality

Limited earlier data suggested variability between peak calving seasons and presumably peak mating seasons in different localities (see Caldwell and Caldwell, 1972: fig. 6-5). Additional data since have not changed the general pattern. For whatever reason, more infants are born in the spring in more northern Florida areas. In southern Florida, fall births predominate. For practical purposes this information is all that is necessary for establishing probabilities, although births may occur year-round. Determination of the causes for the variations have interesting theoretical possibilities, however, in view of the fall births of the same species on the Pacific coast. It is conceivable, that time of birth could be predetermined if the controlling factor could be established. It does not appear to be strictly a matter of water temperature, as south Florida animals (warm water) taken to California (cold water) in our experience both have primarily fall births (also see Caldwell and Caldwell, 1972).

AGGRESSION

The major problem in this area is the aggressiveness of the mature bulls. This includes aggression toward all animals in the tank (Caldwell, Caldwell and Townsend, 1968). Much, but not all, of the aggression is overtly sexual in nature, and infants in particular are in danger of being subjected to such constant harassment that they may die. Bulls are also known to have physically attacked and killed many maturing juveniles. Even the large females may be subjected to considerable stress as well as physical attack.

Oceanaria have coped with this problem in many different ways, but if one visits the larger oceanaria which have both colonies and holding tanks, there is quite likely to be a large bull swimming in splendid isolation in one of the holding tanks while management tries to decide what to do with him. They have usually become attached to him over the years, and he was probably a successful breeding animal during his period

of sexual maturation. During his adolescent period he probably had unlimited access to all of the females in the tank. The females in turn could, acting as a group, control his aggression. There does then seem to be a time span of perhaps two or three years during which maturing males are both successful breeders and the colony can contain him. Ultimately, however, he always seems to wind up swimming around in a holding tank by himself. In the days before the Marine Mammal Protection Act of 1972, when replacements were easily obtained, such bulls were sometimes released.

When at Marineland of the Pacific, John Prescott successfully used a method for getting around male aggressiveness. He placed breeding females in a holding tank with a mature bull for short periods of time and then put them back into the colony. We know little detail of the time of year or duration of the exposure that Prescott used and he should present this information himself. We only know that he achieved successful births and that the colony and the infants were spared the presence of the male when births occurred. Breeding was obviously successful even in such a relatively small and shallow holding tank (again, perhaps Mr. Prescott could give the dimensions).

Although the gestation period for the species is still imperfectly known, the earlier estimates of Arthur McBride at Marineland of Florida of about a year would appear to be holding true. At any rate, peak calving season and peak mating season are at least in close approximation and it is at this time that the mature males are most aggressive and pose the greatest threat to a captive colony. There have been occasions when it has appeared to us that the birth itself served as a sexual stimulus to the males (also see Tavalga and Essapian, 1957). As we have seen males also demonstrate penile erection and forceful intromission as dominance gestures, we cannot be certain of the context in which this behavior occurs when directed toward newborns. We can only state positively that injury or death to the infant may be the end result if the other animals in the tank cannot contain the male. At other times, obviously sexually-aroused males direct their attention to the female which has just given birth. Other females in the tank may come to her assistance when this occurs.

The one potential drawback to the method used by Prescott is that the hopefully impregnated female has to be moved back to the communal tank following exposure to the male. Aborted fetuses and stillbirths occur more frequently in females that have been captured or handled during pregnancy. Nevertheless, if the move is made in early pregnancy, the risk is reduced and the method seems to have definite advantages over having a male in the tank throughout the pregnancy and eventual birth. In a formal breeding establishment, where births were the primary objective, this problem of moving animals could be eliminated through a series of gates and flumes so that the animals to be moved could be herded with nets, or conditioned to move on signals, to avoid physical handling that might be harmful to the pregnancy.

Any stable community in which the animals have established hierarchies reduces aggression. Even adult females are reliably reported to have killed strangers of their own and other species (McBride and Hebb, 1948; Caldwell, Caldwell and Townsend, 1968). If we had the resources to establish a breeding colony (and this is greatly to be desired today) we would begin with animals taken from the same school in a single capture. In such communities, only the slightest of signals from established dominants is necessary to maintain order in the group.

As early as 1940, the keenly perceptive Arthur McBride published information in this area that should have served as a guide to those of us following in his wake, but which has been largely overlooked. He reported a case of two large males, about 260 and 275 cm in length (probably total length) and stated that there was practically no fighting between the two. The larger was dominant during courtship and feeding and aside from occasional jaw-snapping on the part of the dominant the two lived together "very peacefully". McBride clearly stated, "Because the two males were captured together, apparently their social relationship had been determined previously". He also commented upon the persecution that these two inflicted upon a smaller male (about 230 cm, also probably total length) that was captured separately two weeks later and placed in the tank. Recent studies are beginning to suggest that even in a relatively restricted geographical area, small schools of Atlantic bottlenosed dolphins remain segregated even if they pass close by or even

through other small schools. These findings add strength to the suggestion that captures should be made for the breeding colonies not just from a given geographical area, but if at all possible from exactly the same school.

The correlation between number of births, significance of behavioral observations and colony stability was also emphasized by Tavalga (1966). In that paper, the number of adult males in the colony had been reduced to one (Happy) and several successful live births had occurred. We note, however, that the Marineland of Florida records show that even Happy had to be released in November of 1956 as he had become too aggressive toward the females in the tank. His weight at the time is recorded as 236 kg, with a length of 262 cm (total length?).

Artificial Insemination

Artificial insemination is a method that would appear to offer certain advantages over the others. It also requires technology and information that are not available as yet insofar as we know. Methods of obtaining and storing live sperm must be standardized. Blood chemistries of the reproductive hormones need investigation in a highly-structured program. Such programs involve expensive biochemical procedures and the animals will need handling at least on a daily basis and preferably several times daily as these hormones apparently follow several cyclic patterns. Artificial insemination would, however, eliminate most of the social problems encountered in captivity relative to both successful breeding and rearing. In the wild the presence of an adult male did not appear to be a necessary or even a normal component of schools of those species of odontocetes observed by William Evans from an underwater viewing vehicle (see Evans and Bastian, 1969), and to eliminate such a male from a captive breeding colony in which the females were impregnated artificially would not be likely to interfere with the social organization of the colony.

INTERSPECIFIC MIXING

Although successful births and rearings have taken place in dolphin communities with an interspecies mix, such mixes have on occasion posed potential problems. There is often some interspecific aggression (as

well as close relationships), but more to the point we have seen or heard of small stillborn calves or even smaller fetuses devoured by adult animals of another species.

On one occasion at Marineland of Florida, a male Risso's dolphin (*Grampus griseus*) ate a nearly-term stillborn *Tursiops* calf, and on another occasion a large female *Tursiops* ate the small fetus of an Atlantic spotted dolphin (*Stenella plagiodon*). Brown, Caldwell and Caldwell (1966) recorded an instance in which a large male pilot whale devoured a stillborn calf of a common dolphin (*Delphinus delphis*). In all cases the dead carcasses were eaten whole, and were carried by the animal doing the eating for a few minutes (up to 38 in the last case).

While we have no evidence that these events would have taken place had the young been alive, it is something to consider in establishing a colony or expecting successful breeding in an existing mixed colony. The potential might be there for a weak or struggling premature calf to be eaten. We know of no instances of this behavior by any species toward a fetus or calf of its own kind.

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SOME PRELIMINARY IMPRESSIONS ON THE NUMBERS AND SOCIAL BEHAVIOR
OF FREE-SWIMMING BOTTLENOSED DOLPHIN CALVES (*TURSIOPS TRUNCATUS*)
IN THE NORTHERN GULF OF MEXICO

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BACKGROUND

In recent years, for a complex of reasons, institutions maintaining animals in captivity have begun to establish breeding colonies. Associated with these programs have been attempts to identify and control, as far as possible, the biological and social aspects of the captive colonies which will optimize chances that successful mating will occur and that the resultant offspring will survive (e.g., see Caldwell, Caldwell and Townsend, 1968 and Tayler and Saayman, 1972).

Of the numerous marine mammals which have been maintained in captivity none have been more widely distributed, studied or observed by the general public or the scientific community than bottlenosed dolphins, *Tursiops* sp. Since they were first maintained in captivity in 1914 (Townsend, 1914) they have been the mainstays of marine mammal displays and shows at zoos, aquaria and marine parks around the world, and the cetacean species most frequently maintained and studied by research institutions. Since about 1938, successful breeding has occurred in a number of these institutions (e.g., see papers by Wood; Zeiller; Prescott; Caldwell and Caldwell; Shallenberger; and Saayman, this volume). But with a very few exceptions the matings and births have been fortuitous and not part of planned breeding programs. Two notable exceptions have been recent breeding programs at Sea Life Park, Hawaii and at Sea World, San Diego, California.

In establishing colonies of bottlenosed dolphins, or any other species, specifically for breeding purposes, it is essential to consider, in addition to other identifiable factors, any aspects of the naturally occurring density, social structure and behavior of wild populations

which might have some bearing on the success or failure of reproduction and survival of young.

During July 1974, I conducted a series of aerial surveys of the coastal waters of Alabama, Mississippi and eastern Louisiana (Figure 1a). During July 1975, I repeated surveys in that area and conducted similar surveys in Atchafalaya Bay, western Louisiana (Figure 1b). The programs were primarily intended to evaluate various techniques for censusing delphinids from light aircraft and to apply some of these methods to determining density and estimating populations of bottlenosed dolphins (*Tursiops truncatus*) for those areas. The methods and major results are summarized in several publications (Leatherwood and Platter, 1975; Leatherwood and Evans, 1977 (in preparation); Leatherwood et al., 1977 (in review)). In addition to these primary results, however, other data were obtained on the species' feeding patterns (Leatherwood, 1975) and on social structure and behavior of the herds.

This paper presents some preliminary data on 1) the numbers of calves in the herds of animals observed, 2) the positions within the herds of subgroups containing calves, 3) the positions of calves within these subgroups, 4) the interactions between calves and other animals in the herd, and 5) the apparent changes in the behavior of calves with age. I emphasize that although patterns appear to exist in all of these subject areas, the impressions presented here are preliminary and need to be verified by further field observations. Tayler and Saayman (1972) and Saayman and Tayler (1973) provide the only other accounts of a detailed field study of the social organization and behavior of a cetacean species. Their observations suggest that, of the two species reported on in their study area off S. Africa, *Sousa* sp. (initially referred to by these authors as *Sotalia lentiginosa* (Tayler and Saayman, 1972)) is more similar to the *Tursiops* of the northern Gulf of Mexico in terms of herd sizes, behavior and habitat preferences than the *T. aduncus* they observed. Nevertheless, comparisons of the behavior of the two *Tursiops* are made whenever possible.

MATERIALS AND METHODS

Surveys were conducted from a Cessna 172 at altitudes of 152 m and speeds of approximately 165 to 185 km/hr. Whenever dolphin herds were encountered, detailed observations were conducted at this and lower altitudes for from 5 to 25 minutes. Observations were made during all daylight hours from approximately 0730 to 1600. No attempts were made to observe at night.

Whenever possible, the herds encountered were classified in terms of their primary activity patterns as 1) traveling herds, those moving on a continuous heading at a relatively constant rate of speed; 2) feeding herds, those obviously pursuing and taking prey; 3) resting herds, those "laying to" with very little activity or forward progress apparent; and 4) playing herds, those in which there was no feeding and no apparent forward direction but much intraindividual contact, breaching and lobtailing (most of the apparent mating activity was observed during these periods). For a number of reasons, some herds defied classification in any of these four categories. Tayler and Saayman (1972) were able to identify more behavioral patterns and herd configurations in *T. aduncus* off South Africa. They concluded from the behavior of captive bottlenosed dolphins that cessation of locomotion did not occur in free-ranging bottlenosed dolphins because of their inadequate control of buoyancy. During the "resting period" noted in this paper there was little or no forward progress apparent although very slow tail beats were often visible.

Herds were defined as groups of animals which moved together over the period of time of the observation. Although we recognized, as described by Payne and Webb (1971) for example, that the potential for long range acoustic contact among cetaceans may make such a definition of "herd" based on proximity untenable, it seemed the best approach at the time.

Herds were most often composed of identifiable subgroups - smaller units of animals which tended to move as cohesive units within the herd during the time of observation. These subgroups were most clearly identifiable in "traveling" or "resting" herds. But even though herd

structure was generally more loosely defined in feeding and playing groups, these also quickly reassembled into identifiable subgroups when disturbed by a passing boat or by low-altitude passes of the aircraft.

The occurrence and possible significance of these subgroup structures in delphinids were treated by Evans and Bastian (1969). Detailed illustrations of types of subgroups of *T. aduncus* were made by Tayler and Saayman (1972).

Within herds and subgroups, individuals were classified whenever possible as a) calves, young of the year (estimated to be .0 to 1.2 m in length), b) juveniles (estimated to be less than about 2.0 m) and c) adults (estimated to be greater than approximately 2.0 m). Several individuals were identifiable as newborn by visible foetal folds, erratic swimming, and typical bucking of the head at respiration. Subjective estimates of age beyond that time were based on estimates of size relative to accompanying individuals and on behavior.

OBSERVATIONS

Number of Calves

During both surveys the calves of the year were variable in size, suggesting that for *Tursiops* in this region calving occurs at various times throughout the year. During the 1974 survey there were 71 encounters with dolphin groups, ranging in size from 1-175 individuals about a mean of 25.2. Forty-six of the contacts, ranging in size from 2 to 135 individuals about a mean of 19.8, contained 1 or more calves. Overall, calves comprised 7.7% of all animals observed. Individuals clearly classifiable as juveniles comprised 4.7% of all animals observed.

During the 1975 surveys, there were 62 encounters in which group composition was noted, ranging in size from 2 to approximately 125 individuals about a mean of 18.4. Forty of these contacts, ranging in size from 2 to 125 about a mean of 19.4, contained 1 or more calves. Overall, calves comprised 7.9% of all animals observed. Juveniles were not consistently noted, but comprised at least 3.5% of all animals observed. Because juveniles were more difficult to detect than calves, and because an animal was not scored as a juvenile unless it clearly

was not a calf or adult (judged by length), the figures on numbers of juveniles are probably extremely low.

Figure 2 shows the relationship between herd size and the number of calves for the 2 years combined. The herds containing calves carried from 1 to 16 calves about a mean of 3.4 in 1974 and from 1 to 14 about a mean of 3.5 in 1975. Whether the 2 years are considered separately or combined, Kendall's Rank Correlation Coefficient Test (Sokal and Rolf, 1969) demonstrates a significant positive correlation at a 99% level of confidence between the size of herds and the number of calves it contains. While this is certainly not surprising, it does suggest, at least, that reproduction occurs in normally structured herds and that *Tursiops*, at least in this area, does not segregate into special reproductive herds, such as the harem groups noted for sperm whales (Bennett, 1840).

Sizes and Locations of Subgroups Containing Calves

During both years, calves were found in approximately 25% of all subgroups identified, and subgroups containing calves were slightly larger than those containing no calves. In 1974, 79 of the 293 subgroups carefully observed contained 1 or more calves. Those 79 had an average of 5.1 individuals while the 212 without calves averaged 4.7 individuals. In 1975, 75 of the 261 subgroups identified contained calves. Those with calves averaged 5.0 individuals while those without averaged 4.4 individuals.

Subgroups containing calves appeared to differ in their position within the herd depending on the size(s) of calves each carried.

In general, subgroups containing smaller calves were located away from the perimeter of the herd (Figure 3a) surrounded by subgroups with no small calves. This was particularly true in traveling and resting herds. In only four instances in 1974 and six instances in 1975 were the subgroups of large herds which contained calves located on the perimeter of the herd, and in these instances, as in those when herds were disturbed by the aircraft's presence, the calves were quickly moved deeper into the main body of the herd.

While many of the subgroups containing larger calves, presumably more than 6 months old, were also found deep within the herd, they were more often seen towards the herd's perimeter (Figure 3a) and did not often change that position during the time of observation even if the herd was disturbed.

Subgroups apparently containing only juvenile animals were observed, frequently on the perimeter of a herd and sometimes even separated from the herd when first seen by as much as a few hundred yards. Tayler and Saayman (1972) did not observe subgroups composed entirely of juveniles and concluded that two combinations of four age classes (adult, subadult, juvenile and calf) did not occur, i.e., groups of all juveniles and juveniles with bulls alone.

Location of Calves within Subgroups and Treatment by Fellow Subgroup Members

Not surprisingly, the positions of the calves within the subgroups and their treatment by fellow herd members also varied with the behavior of the herd and with the size of the calves.

Newborn and very small calves were never more than a few meters away from at least one adult animal. Just as the subgroups to which they belonged tended to be located away from the perimeter of the herds, the calves within those subgroups also were in 35 of 47 cases in a swimming position which placed them towards the center of the herd and tended to be watched over closely (Figures 3a and b).

In traveling herds these small calves were most often in one of the assisted swimming positions beside or in front of a single adult (Figure 3b) or between two adults swimming abreast (Figure 3c). That these positions afforded the calves some assistance is evidenced by the fact that after a few initial rapid tailbeats these calves often continued to be carried along although there was little or no additional tail movement. The use of ocean waves and bow wakes by dolphins and assisted swimming by calves have been widely documented (e.g., Norris and Prescott, 1961).

The four newborn dolphins I have observed in captivity have generally assumed for 2 to 4 weeks a swimming position which placed an adult

between them and the tank walls (Leatherwood and Cullina, unpublished observations). After that period the calves begin to swim on either side of the attending adult(s) with approximately equal frequency. In the wild, the position of the small calf also appears to be related more to its protection than to any natural tendency to right- or left-sidedness. Juvenile animals and very large calves showed no apparent pattern at any time in choosing one side or the other, despite the herd's activities.

In resting herds where subgroups were still clearly defined, newborn were similarly closely tended by one or more adults and tended to be placed towards the center of the herd. These periods of rest often followed periods of protracted feeding by the adults and preceded periods of play when subgroups were, in general, less tightly maintained. The few instances in which calves were seen nursing occurred during periods of rest. Calves showed their greatest tendency to roam during the periods following nursing, though even then straying small calves were quickly retrieved by the adults.

The most interesting example of this careful vigilance by adults over newborn is illustrated during feeding periods for the adult in what I will refer to as "baby sitting", a behavior I first observed at Marineland of Florida on May 13, 1973. My notes from that date read:

A female *Tursiops truncatus* was held with her calf in the main tank at Marineland of Florida, St. Augustine, along with numerous other bottlenosed dolphins and two spotted dolphins, *Stenella plagiodon*. I observed these animals for about 1 1/2 hours, from approximately 1130 to 1300. During the first half hour the spotted dolphins swam together in close proximity and did not fully intermix with the bottlenosed dolphins. Like the spotters, the bottlenosed dolphin mother and calf swam in close synchrony and remained separate from the other animals.

At the end of that half hour trainers arrived to conduct the dolphin show. From the outset, the spotted dolphins began swimming in wide circles around the perimeter of the tank, a pattern they continued through most of the performance.

At one point the *Tursiops* abandoned her calf to participate in the high jumps. When she did so, the calf immediately joined up with the larger of the two spotted dolphins, took up a close swimming position and remained with it for about 5 minutes.

Circling the perimeter of the tank, the spotted dolphin made no attempt to reject the calf and continued its previous swimming pattern.

When the female bottlenosed dolphin had completed her performance she retrieved her calf from the spotted dolphin and began, as before, to swim in close contact with it separate from all other animals.

In the herds of wild bottlenosed dolphins observed during these studies, when adult females with small calves left the surface for feeding forays their small calves were often taken over and attended by a second adult until the feeding was completed. At that point, the calf rejoined the adult with which it was originally swimming and resumed movement.

These feeding forays were generally brief and were often repeated several times during a period of observation. Baby sitting occurred in each instance observed, although it was sometimes not possible to determine if the same adult tended the young in each instance.

Taylor and Saayman (1972) noted that when lactating mothers entered the surfline to feed, they left their calves in the close proximity of another large animal assumed, by virtue of its external characteristics, to be a male.

As the calves grow during their first year, these patterns of behavior and the degrees of attention given them by adults appear to change. As noted above, subgroups containing only larger calves are sometimes found on the perimeter of traveling or resting herds and are not immediately driven to the center of a herd when the herd is disturbed. They appear in general to be less likely to be in close company of an adult. They stray farther and longer during periods of rest and play. But the developing independence and its possible role in learning are at best illustrated in their behavior during feeding by adults, at the times when babysitting described above is noted for small calves.

In four instances when females with larger calves were observed feeding, the calves could be seen trailing along behind them apparently picking up scraps of fish. In two of those instances the calves, like identifiable juveniles, were seen to independently chase schools of fish. That these independent feeding forays did not always entirely sate the calves' appetites was indicated by the observation of the two calves nursing immediately following feeding.

It was not surprising to see nursing and feeding on whole fish by the same calf. Captive animals may nurse for over a year. Wild delphinids may, also, but appear to be gradually weaned during the first year.

Preliminary data I collected in 1971 for W.F. Perrin on stomach contents of juvenile *Stenella longirostris* indicated successive periods during which the animals feed on exclusively milk, milk and whole food and subsequently exclusively on whole food. Massive additional data support this initial observation for two species of *Stenella* (Perrin et al., 1973) and for *Delphinus delphis* in the Eastern Pacific (Evans, 1975). Vladimir Gurevich (1975, personal communication) has observed an 8 month old *Tursiops truncatus* calf taking whole food while still nursing 8-10 times per day. Similarly, Gary Sharp (1975, personal communication) observed a small *Tursiops* sp., estimated to be less than 4 months old, eating some whole fish in the waters of Revilla Guiguedos, Mexico.

Weaning may be related to the gradual development of an echolocating capability in juvenile animals. In research on ontogeny of echolocation signals in captive *Tursiops*, Evans (personal communication, 1975) noted that when an approximately 14 month old calf was blindfolded and asked to perform a previously trained target discrimination, it produced only a rudimentary echolocation pulse, a signal which apparently required refinement over the subsequent months before it closely resembled the typical adult *Tursiops* echolocation pulse. The lack of pressure on the animal to learn the behavior, i.e., the fact that it was housed with its mother the entire first year and gradually introduced to whole fish, probably accounts in part for its inability to echolocate at this time.

All these observations combine to suggest that these feeding periods during which the growing calf follows the adults are important in the calves' learning to echolocate and that these activities are an important precursor to independent feeding activity.

I have seen a similar development of independence in calves of at least two other cetacean species. In Scammon's and San Ignacio Lagoons in 1971-75, I most frequently found newborn gray whale calves, *Eschrichtius robustus*, (evidenced by small size, foetal folds and numerous snout bristles) deep in the lagoon and in close company of the mother. Larger calves of the season, greater than approximately 4.9 m, were observed straying only late in the year. Similarly, off Maui, Hawaii, in February-March 1975 and 1976, humpback whales, *Megaptera novaeangliae*, appeared to give birth in the shallow lees of the islands and closely tend their calves during the first few months. The only calves observed in open water and those showing the greatest tendency to stray were the larger young of the season (greater than an estimated 4.9 m).

With *Tursiops*, the question of possible dependence of the young on the mother beyond the time of weaning is raised by the observation in three instances of groups of three animals which consisted of a calf, a juvenile and a larger animal, presumably the mother. During each of the observations these three animals moved as a discrete subunit of the herd. Although the larger calf was allowed to stray farther away from the group, it usually returned within a few minutes and maintained close contact when the herd began to move quickly. It noticeably related to the other two individuals during flights from aversive stimuli. In all three cases the smaller calf was a very small newborn.

Protection of Calves from Aversive Stimuli

When a herd was disturbed and began to "run" from the boat or aircraft, small calves continued to ride in an assisted swimming position, but often took up a position directly in front of the adult(s) (Figure 3c).

In the few instances when we inadvertently made passes too close over a group containing calves, and their "run" was insufficient to outstrip us, the adults frequently placed the calves beneath them and forced them below the surface (Figure 3d). When this type of behavior was

observed we immediately climbed to higher altitude. In these instances the herds frequently slowed, presumably to rest, and the calves remained at the surface for protracted periods.

Both newborn and estimated midyear calves were frequently shielded from aversive stimuli in this manner. Even as they rode the bow pressure waves of moving boats the adults stationed themselves between the boat and the calf. So complete is the protection that in numerous instances while observing bow-riding dolphins (*Delphinus delphis* and *Lagenorhynchus obliquidens*) from submerged viewing ports of a research vessel (see Evans and Bastian, 1969) we were often unaware of the presence of a calf until the animals terminated riding and began to move away from the vessel. Scammon (1874) and others have described similar behaviors for gray whales shielding their young and are readily observable in humpback whales and pilot whales *Globicephala* sp. (unpublished observations).

Taylor and Saayman (1972) noted that when the animals were in extreme alarm reaction subgroup structure broke down. In our observations the calves were closely attended during these periods and the subgroups appeared to be maintained.

One such aversive stimulus appeared to be large animals, which I assumed to be males. Several times, when herds were resting or playing, the large adults, frequently solitary individuals on the perimeter of the herd, would make high speed rushes at a female and her calf. The female shielded her calf in every instance. In two instances, when the shielding did not stop the advances, the female rushed the "attacker" chasing it away. It was not clear whether these advances represented attacks on the calf or solicitations of the female.

Essapian (1963) reported captive *Tursiops* straying from their mothers at an early age (2 to 3 weeks). We have observed similar early straying in captive *Tursiops* calves at NUC and Sea World of San Diego (Leatherwood and Cullina, unpublished observations). The freedom afforded the young in the captive situation may well be related to the uninterrupted acoustic contact between the mother and the calf and the absence of natural predators in the tank.

In at least 39 of the 71 encounters in 1974 and at least 20 of the 64 encounters in 1975, there were sharks with the moving herds of dolphins. They may have been present in other instances as well but not detected in the turbid waters. In four instances, sharks were observed feeding with porpoises on the same schools of fish. This is of particular interest because, although the sharks moved freely behind and occasionally among the herds of dolphins, I never saw any signs of aggression by a porpoise towards a shark. Wood, Caldwell and Caldwell (1970) discuss the best evidence to date on the interrelationships between sharks and *Tursiops*, citing frequent occurrence of healed scars from shark bites on the dolphins. Leatherwood et al. (1972) cite similar evidence for *Delphinus* and *Stenella* and develop the idea that the sharks present with the moving herds of tuna and porpoise are like the moving, veldt communities of herbivore, predator and scavengers.

The frequent occurrence of sharks in the highly turbid coastal waters of the northern Gulf may well explain the close attention of adult *Tursiops* to young calves.

SUMMARY AND DISCUSSION

This paper has presented observations on the number of bottlenosed dolphin calves, on the position within the herd of subgroups containing calves, on the position of the calves within these subgroups, on interaction between the calves and other animals, and on changes in the calves' behavior with age. These observations must be regarded as preliminary, but they offer points of discussion that may yield insight useful in the establishment of breeding colonies of captive mammals.

The numbers of calves observed most closely reflects a model of a population with a mean calving interval of 3 years. For example, if one assumes half this population to be females, half of those to be of breeding age and half those to be calving in a given year, then one would expect calves to constitute 12.5% ($100\% \times 0.5 \times 0.5 \times 0.5$) of the population. If one assumes, however that females are calving on the average of only once every 3 years ($100\% \times 0.5 \times 0.5 \times 0.33$) then calves would be expected to constitute 8.5% of all animals observed. With these highly

tenuous assumptions, the observed percentages of 7.7% in 1974 and 7.9% in 1975 suggest a 3 year calving interval for this stock of *Tursiops*.

A second interpretation of these data suggests a 2 year calving interval and yields even higher productivity figures for the stock. Data presented by Caldwell and Caldwell (1972) and expanded by contributors to this volume indicate that at least captive *Tursiops* exhibit calving peaks during the fall and spring seasons. All available data on growth rates of these captive-born calves indicate that they approach or exceed 2.0m by the end of their first year (Ridgway, 1977 pers. com.). If both these patterns hold true for this free-swimming stock of *Tursiops*, then the animals classified as calves during the summer surveys reported in this paper could be from the spring peak while those classified as juveniles, just less than 2.0m in length, could be from the fall peak the previous year. If the figures for these two groups are added, annual minimum calf production figures of 12.4% (1974) and 11.4% (1975) are obtained. These figures are in line with the majority of the production figures reported for wild odontocete populations; e.g., 13.3% pregnancy rate for *Orcinus orca* (Jonsgard and Lyshoel, 1970) and production rates of 14.0% for *Delphinapterus leucas* (Sergeant and Brodie, 1975) and 14.4% for *Stenella attenuata* (Perrin, Coe and Zweifel, 1975ms).

Information on most aspects of the reproductive biology of *Tursiops* is inadequate. But as data become available to refine the assumptions stated above, percentages of calves observed during similar surveys of wild populations can be used to assess viability of those stocks and to predict productivity in a captive colony not subjected to programs to increase natural calving rates.

The observations on treatment of calves by fellow herd members and on the development of independent behavior by the calves agree with reported patterns in captive *Tursiops truncatus* (e.g., Tavalga and Essapian, 1957 and Essapian, 1963), in other wild *Tursiops* (Tayler and Saayman, 1972; Saayman and Tayler, 1973) and in other delphinids (e.g., Evans, 1975) and with patterns I have observed in two mysticete (grey and humpback whales) and three other odontocete species (*Lissodelphis borealis*, *Delphinus delphis*, *Lagenorhynchus obliquidens*). Even so, they must be interpreted cautiously.

After long-term observations from a high land vantage point, Tayler and Saayman (1972) noted that social organization in both *Tursiops aduncus* and *Sousa* sp. is highly variable, depending on the time of day, number of animals and form of activity. The apparent patterns in northern Gulf *Tursiops*, however realistic they appear, are supported to date by relatively short-term observations in a rather limited area. That the information is from the Mississippi Sound is of particular importance, I think, because of the recent increase in the capture of animals from that area instead of from some of the previous areas of capture off south and west Florida (see Odell, Siniff and Waring, 1975). Perhaps the most important reason for reporting these preliminary impressions is to emphasize several points.

Cetaceans are among the most difficult of all animals to study in their natural environment. Many of the problems which have made them such poor subjects for field observations are identified and some attempted solutions are discussed by Leatherwood and Evans (1976). And it is only recently, with the use of such approaches as long-term observations of coastal species from shore vantage points (Tayler and Saayman, 1972; Saayman and Tayler, 1973) and the use of such techniques as underwater platforms (Evans and Bastian, 1969; Norris, 1974), radiotelemetry (e.g., Evans, 1971; Evans and Leatherwood, 1972; Norris, Evans and Ray, 1974) and extensive use of low-altitude aircraft (Leatherwood, 1974; 1975), that detailed field studies of cetacean behavior have become practical. Because of these difficulties, behavioral work with cetaceans, particularly free swimming cetaceans, continues, as noted by Caldwell and Caldwell (1972), to be in the naturalistic stages.

The numerous captive individuals and colonies have afforded behaviorists good opportunities to observe the animals at close range for extended periods of time. Since the best studies of the behavior of captive bottlenosed dolphins (e.g., McBride and Hebb, 1948; McBride and Dritzler, 1951; Tavolga and Essapian, 1957) generally preceded the relatively recent field studies, most of us have taken our impressions of behavior based on the captive animals into the field as the filters through which we viewed the behavior of the wild animals. But some of the experience with long-term field observations of primate behavior (e.g., Goodall-

van Lawick, 1967; Schaller, 1963) suggests that observations of captive animals may be misleading. As it becomes possible we should interpret the behavior of captive specimens in the light of field studies of wild animals.

For all these reasons, as we consider establishing captive breeding colonies of bottlenosed dolphins, it is important to consider those factors of natural density, subgroup associations, and behavior which may have some influence on the success of the captive colony.

DISCUSSION

Dr. Shallenberger: Steve, I was very interested in your comment that the calves tended to be near the center of the herds. In Hawaii, the *Tursiops* calves we see are frequently out near the perimeter. Of course we are looking from a boat, and the different vantage point from an airplane might change that impression.

Leatherwood: That's interesting. As you know I have seen too few *Tursiops* in the wild in Hawaii to comment. But even if we assume there are consistent differences between the positions of calves in the two areas, one might speculate that the closer attention and protection of youngsters in the Gulf is related to the turbid waters there and the constant presence of sharks. I don't otherwise know how to account for it.

Dr. Saayman: Are you able to identify individual animals?

Leatherwood: Although we have been able to on occasion with other species, not yet with *Tursiops*. The best we have been able to do is tentatively identify herds based on the number of individuals, the composition of the group and its behavior. One group we saw off Cat Island, Mississippi, in 1974, for example, had 62-65 individuals including 8 females with calves. A group with that description was seen near the island four times one year. The last time, a day following

a set on it by local fishermen collecting dolphins, the same group began to run from the collection boat which was in the area. The next year, 1975, we made two sightings of herds of 60 and 62 animals. I think these were the same in each instance.

Dr. Allen: Do you ever see nursery schools?

Leatherwood: No, John, we haven't. I have read about nursery schools and was on the lookout for them but with no luck. In our paper on the population estimate for the area we did note having seen groups which consisted of all adults and others which consisted of all yearlings. And as I remember, we have records of these yearling schools for *Delphinus* and *Lissodelphis* too. These groups were never the very small calves but were probably yearlings or at least older young of the year. I have no idea when in the year they might begin to form those groups.

Dr. Van Heel: On your observation of baby-sitting, it is not restricted to adults. In our aquarium, a yearling often baby-sits a calf while its mother goes to feed.

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LIST OF FIGURES

Figure 1. The study areas for the dolphin aerial surveys.

- a) Mississippi Sound (1974 and 1975), Chandeleur and Breton Sounds (1974 only).
- b) Atchafalaya Bay (1975 only).

2. The relationship between herd size and number of calves, 1974 and 1975 surveys combined.

3. Some graphic representations of behaviors described in the text: Typical positions of calves within travelling or resting herds and within their subgroups (a)

Assisted swimming positions for a calf accompanying one (b) or two (c) adults; protection of a calf from aversive stimuli from above (d), beside (e) and below (f). (Modified after Tayler and Saayman, 1972).

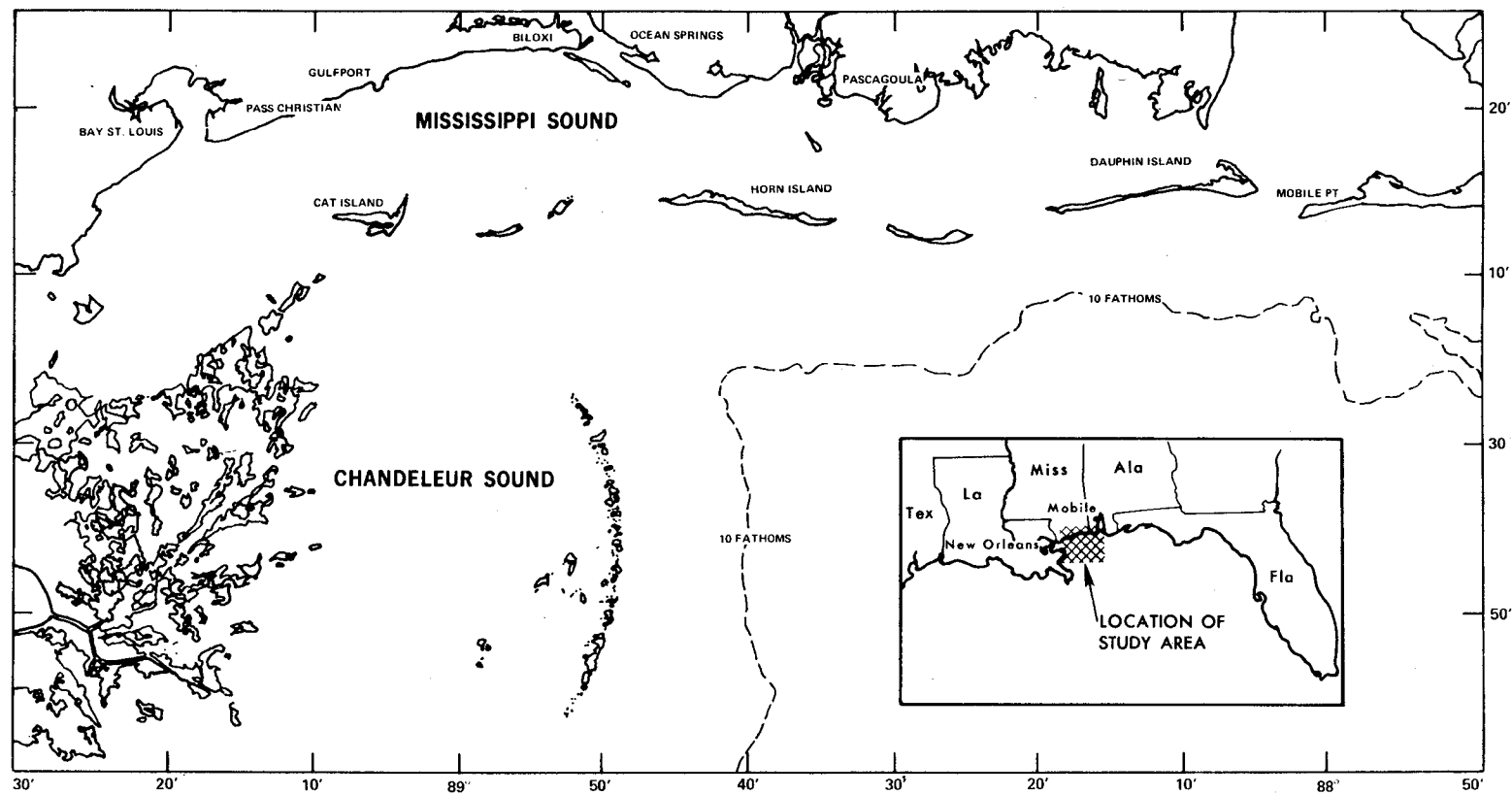


Figure 1a.

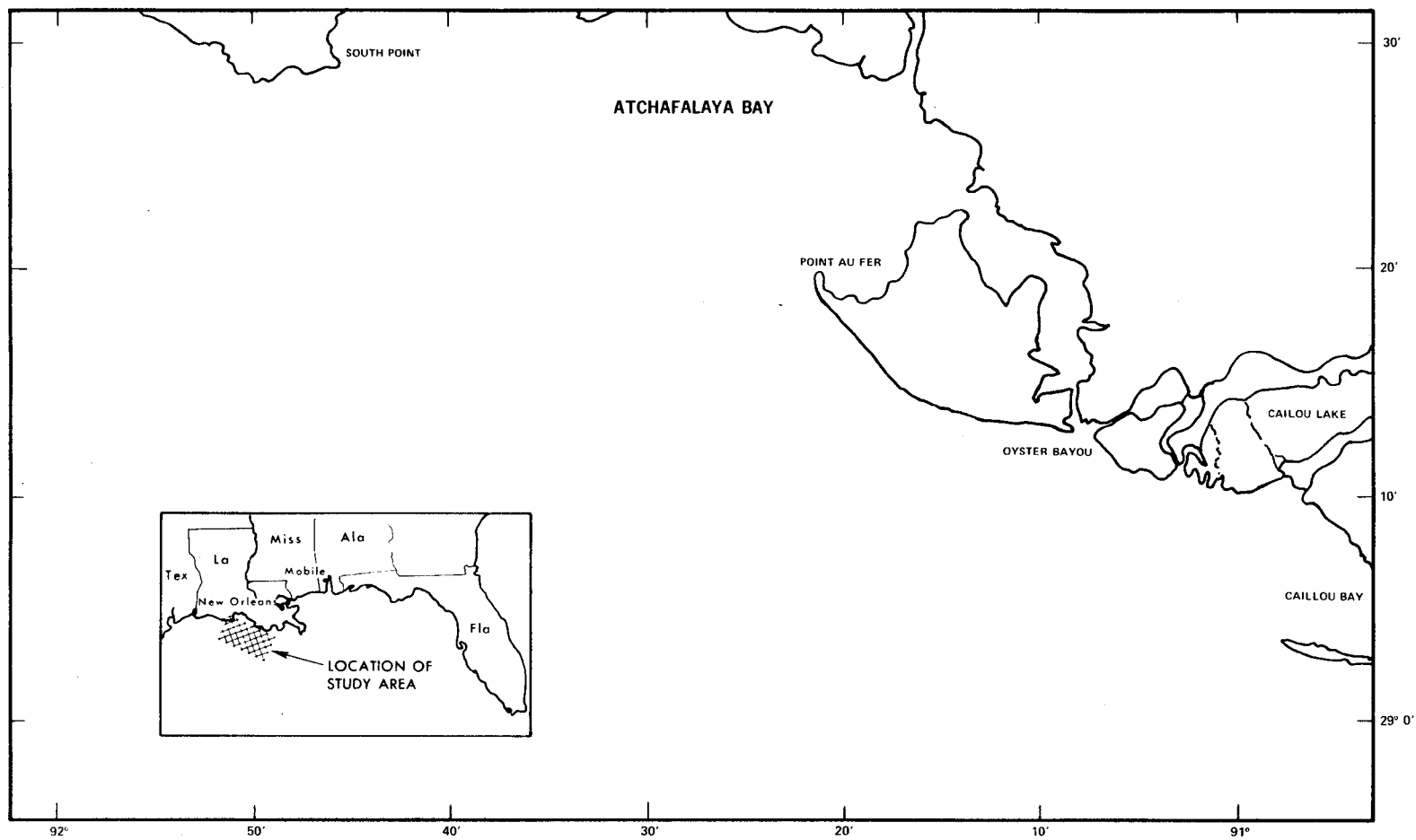
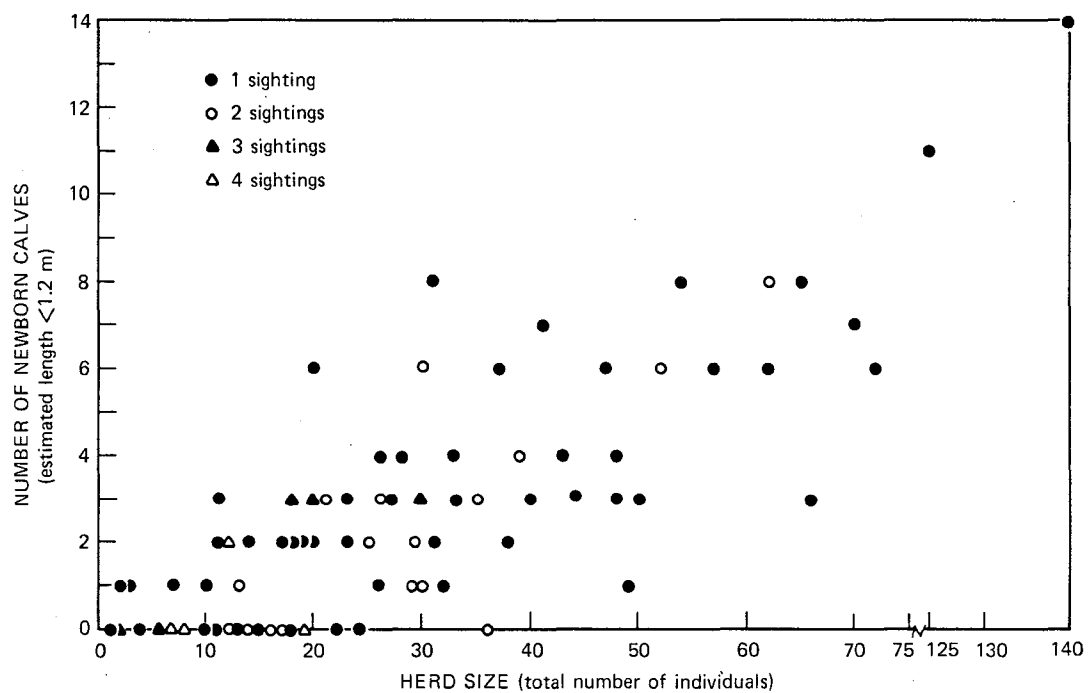


Figure 1b.



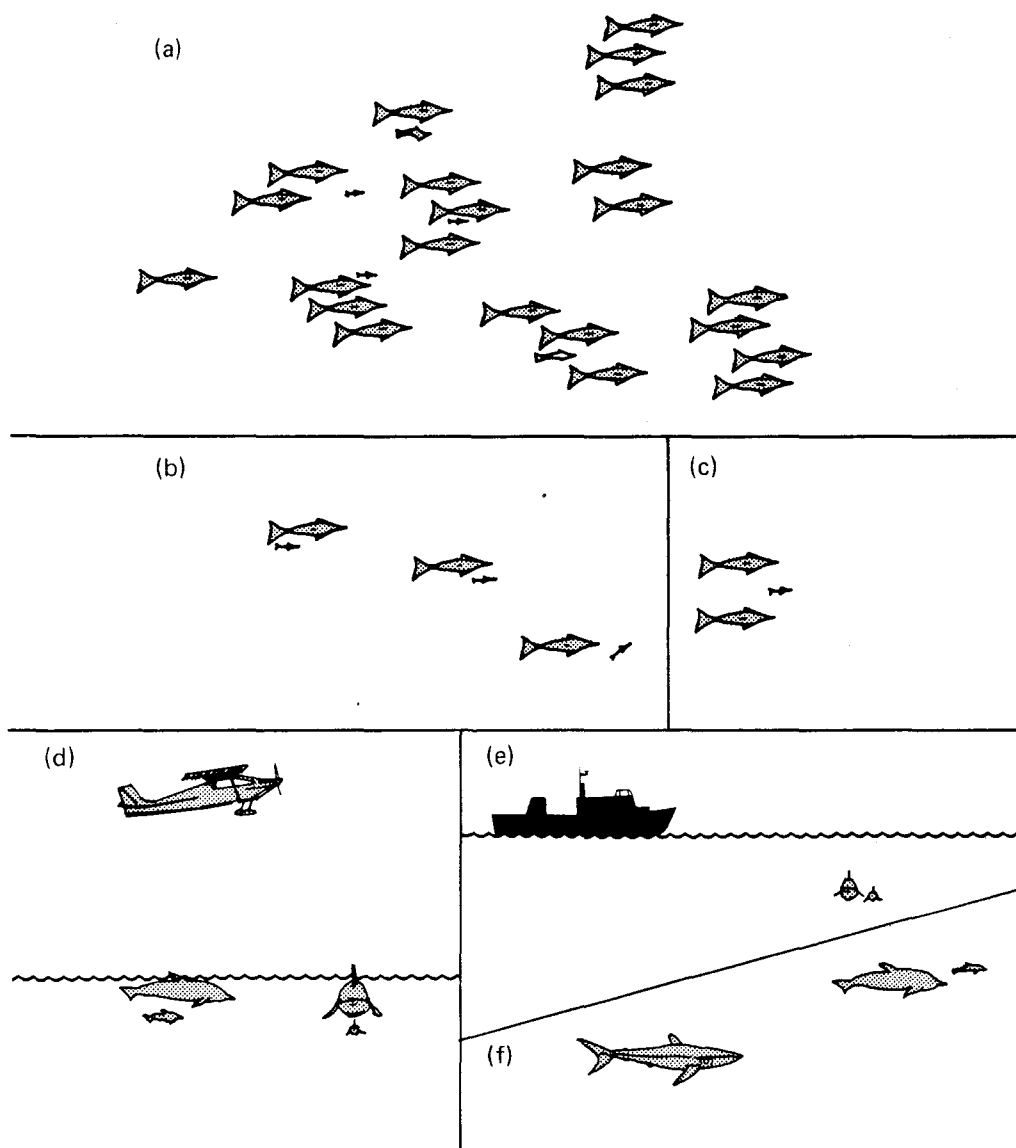


Figure 3. Some graphic representations of behaviors described in the text: Typical positions of calves within travelling or resting herds and within their subgroups, (a); assisted swimming positions for a calf accompanying one (b) or two (c) adults; protection of a calf from aversive stimuli from above (d), beside (e) and below (f). (Modified after Tayler and Saayman, 1972).

POST-NATAL BEHAVIOR OF AN ATLANTIC
BOTTLENOSED DOLPHIN CALF (*TURSIOPS TRUNCATUS*, MONTAGU)
BORN AT SEA WORLD

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INTRODUCTION

The observations reported here on the behavioral patterns of a newborn Atlantic bottlenosed dolphin (*Tursiops truncatus*, Montagu) were made during the interval from time of birth, April 17, 1975, to date. The main purpose of this investigation was to collect data regarding the behavior of this newborn dolphin during the first year of life in captivity.

During the course of this study, observations were made on the development of social behavior between the neonate and the group of adult dolphins in its pool, as well as the relationship between the calf (Moby), its mother (Jiffy) and people.

We observed respiratory activity of the calf and several adults under various circumstances: swimming, nursing, demonstrative, imitative, sexual behavior and the development of playing behavior. In addition, we tried to develop a relationship between the calf and humans.

MATERIAL AND METHODS

Our observations can be divided in two periods--the first from April until September. During this time, four adults and the calf were under observation. Three adults were Atlantic bottlenosed dolphins and one was a female Pacific bottlenosed dolphin (*Tursiops gilli*). At this time, the dolphins were being kept in a 170,325 liter circular tank, 10.7 m in diameter and about 2.4 m deep at the center.

During the second period, which extended from September until December 1975, Jiffy and Moby were kept in isolation in a small tank about 6.1 m in diameter and 1.5 m deep at the center. Periodically, two other Atlantic

bottlenosed dolphins, Chuck and Julio, were introduced into the same tank for considerable periods.

Observations and respiration activities were recorded daily at various times between 0800 and 1700. Similar observations were undertaken during several nocturnal sessions. Respiration counts were made using a combination of visual sighting and stop-watch. Data were recorded in actual elapsed time from one respiration to the next over a fifteen minute interval. In addition, we counted average respiration rate during the same 15 minute as well as 5 minute periods. During this study we used terminology which was established by previous investigators working on the same problem: McBride and Hebb (1948), McBride and Kritztler (1951), Essapian (1953), Tavalga and Essapian (1957), Andersen and Dziedzic (1964), Caldwell and Caldwell (1966).

Respiration

During the entire period of observations the respiration activity of the calf varied depending on the time of the day and general situation in the tank, including numbers of other animals and degree of behavioral activity. We obtained much data concerning respiratory activity during all of the conditions mentioned above (see Graphs No. 1 and 2).

At night, during short naps, or prolonged periods of sleep, nursing behavior or monotonous swimming, the respiration activity slowed, sometimes to half the rate observed during very active swimming, playing, chasing and so forth. In addition, I want to note the relationship between the frequency of respiratory activity and the age of the calf. As the calf grew older, the rate of respiratory activity slowed slightly. For example, during the first days of life the respiratory rate ranged from 5 to 8 respirations per minute and slowed during nursing or sleeping periods to from 3 to 5 per minute. Between 3 and 4 months the respiratory rate decreased further to 3-4 per minute during normal activity. At the present time (December 1975) the normal respiration rate is 2-3 times per minute during quiet swimming or nursing, but increases to 5-6 per minute during post-feeding active swimming behavior, playing with different objects, or sexual activity.

Nursing Behavior

During the first three months when the calf shared the tank with four other adult dolphins, including his mother, he was observed to initiate nursing most frequently by nudging his dam in the region of the mammary glands with the rostrum (Figure 1)*

For approximately the first three months the typical position assumed for nursing involved Jiffy's turning on her side and exposing the ventral surface of her body to the calf. The young turns on its opposite side and begins nursing as both swim in a ventral-to-ventral position (Figure 2).

The calf's average respiration rate during nursing, at this age, was 3-4 respirations per minute. Nursing was observed for a duration of approximately 7 to 10 seconds; this nursing behavior usually occurred only once per 15 minutes observation. Later Jiffy ceased to turn on her side, forcing the calf to assume almost an upside down position in order to nurse. In this position the calf would nurse only for 4 to 6 seconds, but was observed nursing up to four times during a 15 minute nursing period. At this time the respiration rate ranged from 2.2 respirations per minute during quiet swimming to 5.7 during nursing (Figure 3). At the age of 6 months and to the present time the average number of nursing periods during the day are 3-4 times in one hour, with duration of each nursing from 4 to 10 seconds.

Playing

Several play activities occurred spontaneously and were repeated thereafter. The most frequent type of behavior was chasing and accelerated swimming. Accelerated swimming has been observed during periods of stress, but has also occurred spontaneously after feeding, during play activity and at times of sexual behavior.

At the age of 2 months the calf had been observed many times swimming at high speeds by himself and with one or more adults; this activity was often accompanied by jumping out of water. Accelerated

*All photographs were taken by the Sea World staff photographer.

swimming was often paired with chasing. Chasing in porpoises has been described as precopulatory behavior by Andersen and Dziedzic (1964) but the calf's swimming patterns, at this time, were apparently indicative of play.

When the calf was 6 months old we began to introduce different objects into the pool such as a ring and a ball. The first reaction to the introduction of these new objects was fright. Neither Jiffy nor the calf made any attempt to approach the ring or ball. They simply ignored them. After the other female, Chuck, was reintroduced into the tank and was observed to play with the ring, the calf began attempts to imitate Chuck's playing behavior. This occurred on the fourth day of the daily presentation of the ring in the tank.

Six days after the ring was first introduced into the pool it became the calf's favorite toy with which it played for hours, diverted only by playing with fish or contact with adult animals. For instance, he discovered for himself the following game. He started to pull the ring down to the bottom of the tank, then let go and watched it float to the surface. As soon as it reached the surface he would pull it down again. In addition, after only 8 days, he was able to demonstrate very complex manipulation and balancing with the ring, carrying the ring by hooking it on his rostrum and tossing it around the tank. On occasion, he placed the ring on the dorsal or pectoral fins and swam around the tank for a considerable time.

Soon we began to introduce two objects simultaneously into the tank, and during more of his daily activity the calf played either with the ring or the ball. Although playing activity with the ball was frequent, the calf preferred the ring to the ball if both were present in the water. Occasionally he would attempt to play with both objects at one time, carrying the ring in his open mouth and at the same time butting the ball with his head. He soon learned to return the ring to an observer after it was thrown into the pool and waited for a pat or stroking as a reward. At times, however, he seemed to prefer play with adult animals even though the ball and ring were in the tank.

Sexual Behavior

The first sexual activity between Moby and his dam was observed on November 4, 1975. Moby initiated this behavior as he and Jiffy were calmly circling the tank. It started when Moby rolled over onto his back and swam underneath Jiffy, pressing his genital area to hers for a few seconds. Then, swimming around behind Jiffy, he repeated this same action. After Moby repeated this a few times Jiffy became angry and slapped him with her rostrum, causing Moby to cease and swim away from her. The next sexual activity was observed three days later. Moby initiated it the same as before but this time he chased Jiffy around the tank several times. In this case Jiffy gave no angry response, so this period of sexual activity lasted for several minutes.

The day when Chuck was reunited with Moby and Jiffy, the calf started approaching her sexually in the same manner. Later, during daily observation periods Moby's sexual activity occurred at least once a day and lasted an average of 6 to 7 minutes. On some days he exhibited sexual activity with Jiffy and with Chuck in turns. During one 10 minute period Moby approached both Jiffy and Chuck several times, alternating back and forth from one to the other.

When Julio, a male from the next tank, was moved into the pool, Moby's sexual behavior changed greatly. Moby spent most of his time with Julio and initiated sexual behavior with him much more frequently than he had with either Jiffy or Chuck. There was no sexual activity between Moby and the females while Julio was in the same tank. After Julio was moved back out of the tank, Moby went back to his normal sexual activity with Jiffy and Chuck.

Courtship by Moby involved the following behavior patterns: chasing, stroking, cross-swimming, posturing, rubbing, belly exposure and erection. The calf was observed to take the initiative in courtship with both females as well as in homosexual behavior with the male.

Behavior During Feeding Time

During the first days of his life the calf swam alongside its mother while the other adults fed (Figure 4). After the adults fed to satiation,

the two females took over supervision of the baby in turn, and swam with him while Jiffy ate.

At the age of 2 months, the calf began to show an interest in fish thrown into the tank while he was swimming with adult dolphins during feeding. After the transfer of Jiffy and her calf into the small tank at an age of just over 4 months, the behavior of the calf appeared similar to that of the adult animals during feeding.

Development of this behavior occurred gradually and appears to be a good example of learning through imitative behavior. When the observer arrived with food for the adult animals, the calf followed them over to the feeding area. But usually the calf soon left the feeding area and went over to the gate which connects the two tanks. At this position Moby vocalized until Julio, the male in the adjacent pool, came up to the gate connecting the pools. This behavior was observed frequently. Further, the calf stayed behind his mother and Chuck in order to pick up fish that had been dropped by the adults. When the calf would grasp, but not eat the fish, he oriented it head first in his mouth. He closed his mouth over the fish and swam around, but soon spit out the fish.

Resting

The typical resting position, with the blowhole exposed and the tail down, was not seen in either Jiffy or her baby until the latter was approximately 5 months old. After that, they, as well as other adults, have been observed in this position. The adult animals swam with their eyes closed only for brief periods during the day, mainly after receiving food. It was never possible to observe the duration of swimming behavior with closed eyes for more than 5-10 minutes. The calf was observed to sleep only when in the exclusive company of its mother. While his eyes were closed, the calf was always with the mother (Figures 5 and 6). Sleep was observed in the morning and evening, as well as at noon, especially on warm and sunny days, and continued from a few minutes to an hour and a half. Swimming activity when the eyes were closed was slow and monotonous. Respiratory activity slowed to about half that observed during the normal daily swimming activity. In conclusion, it appeared to me that this calf was capable of deep sleep which continued for one hour or more.

Relationship between the Calf and Human Observers

At the age of about five months Moby and Jiffy were moved to a smaller tank to make it easier to reach them in order to establish a human relationship. For this purpose a ring and ball were used to gain Moby's attention and bring him over to the side of the tank in front of the observer. The ring was held at arm's length into the water and splashed slightly. Moby would cautiously approach the ring for short periods, staying about 6 inches away from it. If any motion was made by the observer to reach out towards him, Moby would leave immediately. He would also leave if Jiffy came up and nudged him with her rostrum. Gradually he became braver and would inch his way in closer, then gently touch his rostrum to the ring and leave very quickly. On the fourth day Moby hooked the ring on his rostrum and pulled it from the observer's hand. He would not do this again for five days, but then he started taking it without any hesitation. After this, whenever Moby took the ring from one hand, an attempt at touching him was made with the observer's other hand. On November 4, 1975 Moby touched the observer's outstretched hand with his rostrum for the first time. Immediately following this he allowed the observer to pet him on the rostrum and melon for a few seconds at a time. After a few days of this, Moby allowed the observer to pet him for a longer period, often on the back and around his dorsal fin. Eight days later he rolled over, so that his thorax could also be petted and loose skin rubbed off. When Jiffy and Moby were the only animals in the tank, he would come up to the observer frequently to be petted. This ended when Chuck was returned to the tank; Moby preferred swimming and playing with her more than being petted by the observer. He would come up to be petted only occasionally when Chuck ignored him.

At the end of the observation period Moby was spending more of his time playing with the ring than with Chuck. This made it easier to get him over to the side of the tank to be petted than it was when Chuck was first brought back. Sometimes Moby would come over to be petted on his own, but most of the time the observer had to slap the water or the side of the tank and Moby would come over. Jiffy and Chuck both appeared "jealous" of Moby being petted by the observer. Whenever he was petted,

one or both of them would come up and nudge Moby away. They would also nudge the observer's hand away when it was in the water.

SUMMARY

Observations were made of a dolphin calf during its first 7 1/2 months of life at Sea World in San Diego. The behavioral patterns observed were divided into several categories, such as nursing, playing, resting, sleeping, swimming, sexual, imitative, straying and exploring behavior, behavior during feeding time, discipline, respiratory activity, relationships with humans and with other dolphins. These natural behavioral patterns as well as artificially induced behavior can perhaps be seen as part of the complex relationships which arise during the first year of life in the process of active learning, such as imitative behavior.

It therefore appears that those forms of playing activity which accompany specific locomotor, posture and sound signals indicate that early learning, together with interaction of the instinctive components of behavior, undoubtedly have great significance during the entire course of post-natal development.

The results I have presented should be regarded as preliminary because I plan to continue this study for at least 6 more months.

ACKNOWLEDGEMENTS

I would be remiss if I did not acknowledge the generous help given me by Dr. Lanny H. Cornell, Vice-President Research/Veterinary Husbandry and Corporate Curator of Marine Mammals at Sea World, Inc., San Diego, CA, in providing access to the Atlantic bottlenosed dolphins, both dam and calf, as well as the other dolphins who were part of this study.

Technical assistance in recording data on a daily basis was provided by James Berman, student of Moorpark College, Moorpark, CA and Cathy Dargan, a junior at James Madison High School, San Diego, CA.

I would also like to thank my colleagues and many others who have helped to carry out the observation and analyses of the data presented here.

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- Figure 1. The calf initiates the nursing by nudging his mother in the region of the mammary glands.
2. Typical position for nursing which occurred during the first three months of the calf's life.
 3. Typical nursing position which first occurred after three months and which continues to this day.
 4. One of the typical patterns in which the animals are calmly circling.
 5. and 6. Typical resting position during sleep. It can be seen that the calf's eyes are closed.

*All photographs were taken by the Sea World staff photographer.

GRAPH 1: RESPIRATION ACTIVITY OF THE
CALF OF AN ATLANTIC BOTTLENOSED
DOLPHIN (*TURSIOPS TRUNCATUS*)
(AT AGE FROM 5 TO 8 MONTHS)

GRAPH 2: RESPIRATION ACTIVITY OF THE ATLANTIC
BOTTLENOSED DOLPHIN (*TURSIOPS*
TRUNCATUS) (THE CALF IS AT AGE FROM
6 TO 8 MONTHS)

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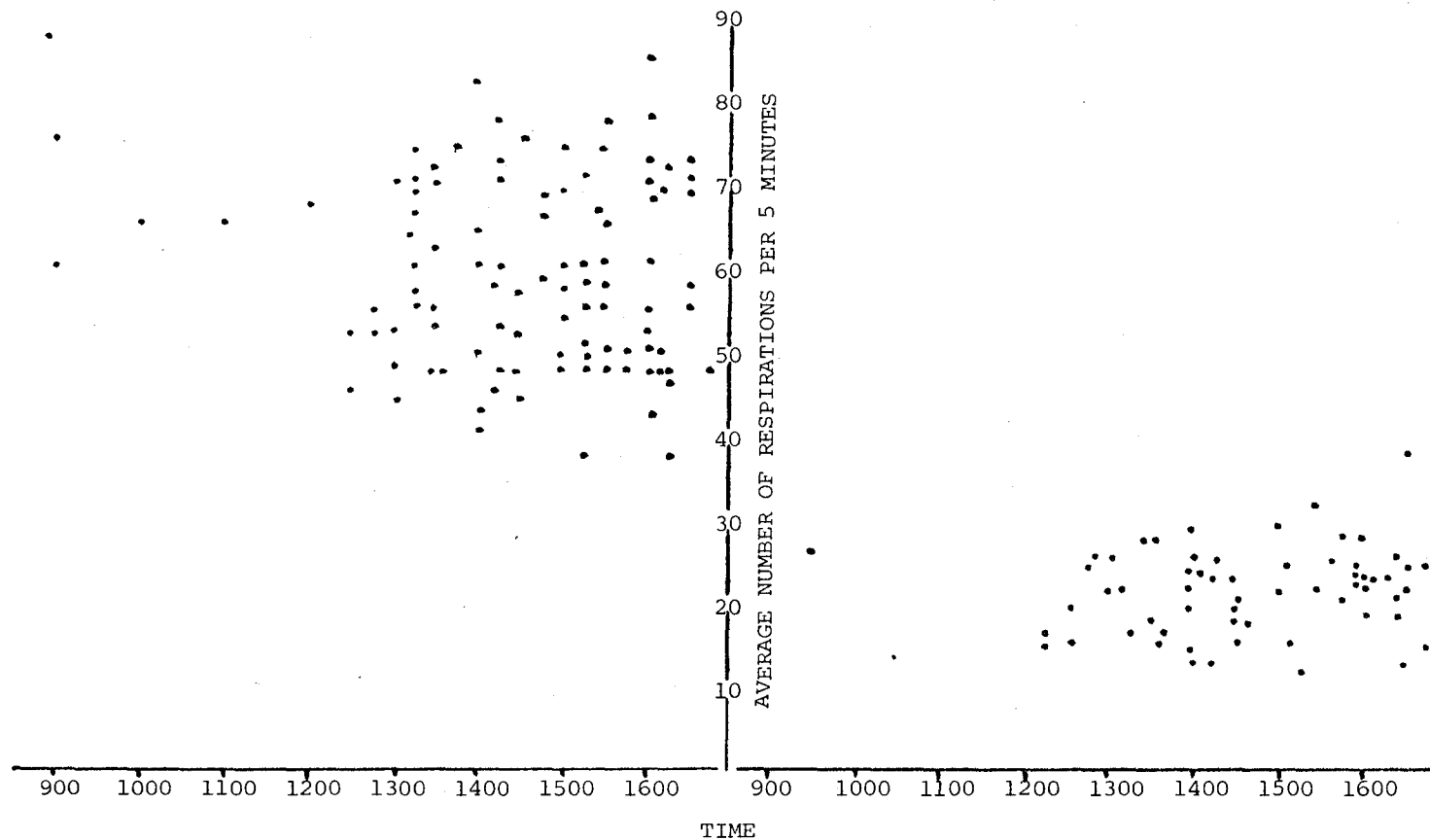




Figure 1



Figure 2



Figure 3

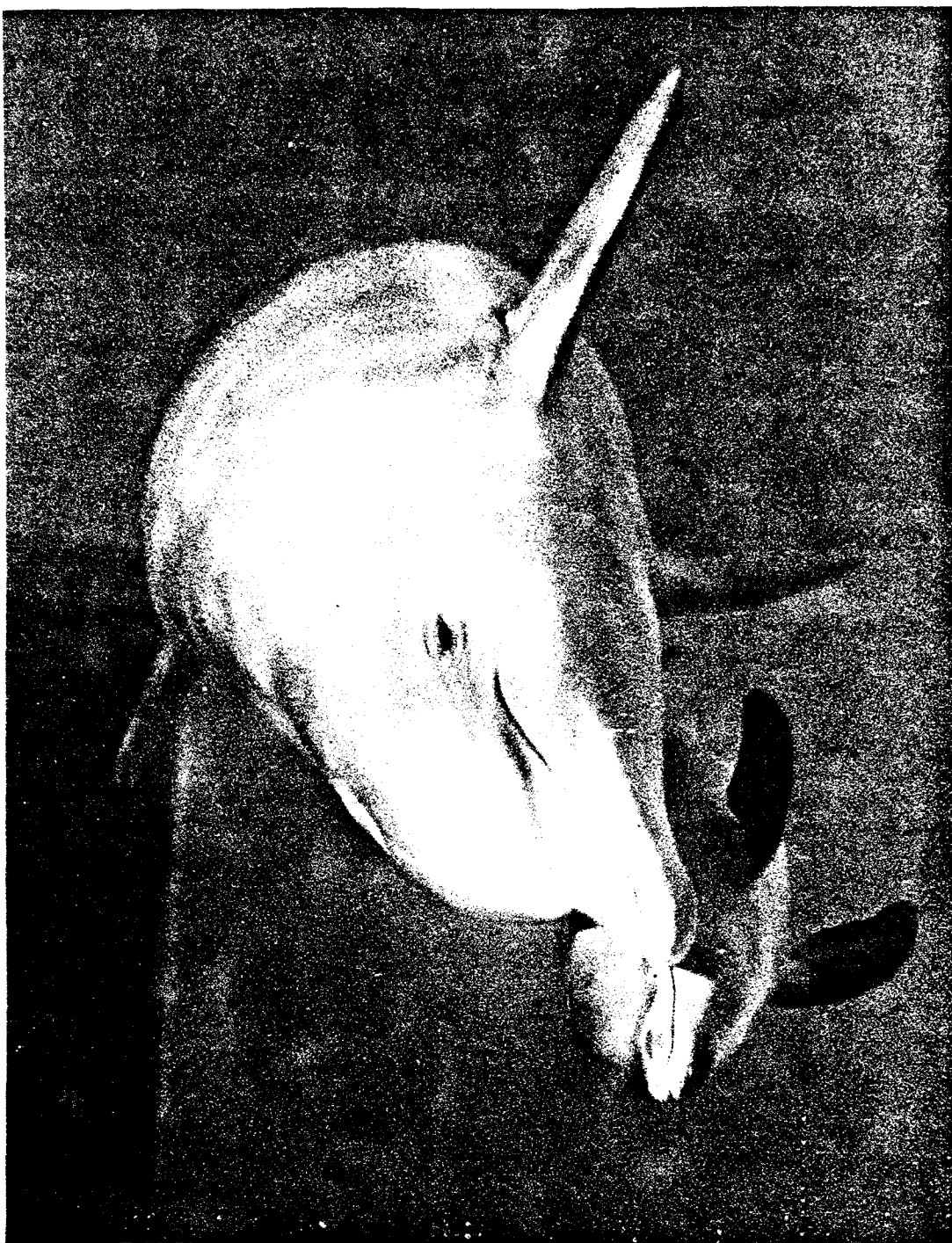


Figure 4

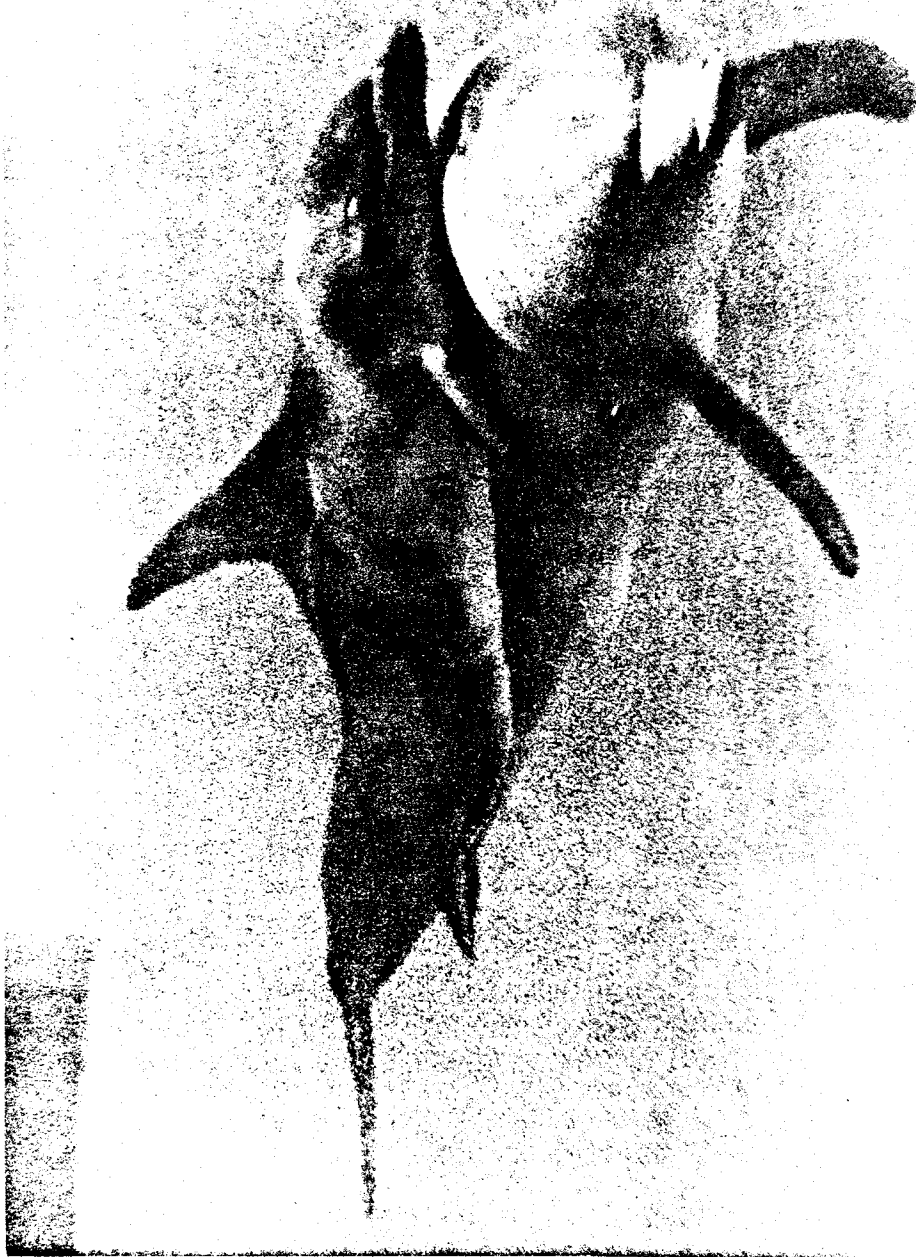


Figure 5



Figure 6

GROSS ANATOMY OF THE REPRODUCTIVE ORGANS IN DOLPHINS

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If one wants to learn about the reproductive anatomy of dolphins, I suggest a study of the animal in question, rather than a search of the literature. There are only a few papers dealing with reproductive biology, and still fewer dealing with reproductive anatomy. The most complete discussions are by Meek (1918), Slijper (1962 and 1966), and Harrison (1969). Additional accounts deal more specifically with one sex or the other, or with some specific reproductive organ. These include papers by Hepburn (1902), Pycraft (1932), and Ping (1926).

The sexes in cetaceans are easily distinguished by differences in the external genital organs. In the male dolphin the anal opening is some distance posterior to the penial sac. There are in some males from one to several small openings, lateral to the pouch, which may contain reduced nipples. In the female the anal and genital openings are so close together they most often occupy the same groove along the mid-ventral surface. There is usually one or more slit-like openings along each side of the vulva housing the nipples of the mammary glands.

Female Reproductive Organs

The external female organs consist of the slit-like vulva with major and minor labia. There is extensive variation in the degree of development of the labia, probably a product of age as well as species differences. The clitoris projects posteriorly into the anterior genital slit from a mass of tough, fibrous connective tissue. It has a thick tunica albuginea, a corpus cavernosum clitoridis, and in some species a corpus cavernosum urethrae.

The muscles in this area consist of ischiocavernosus (erector clitoridis); sphincter vaginae (vaginal band) and retractor clitoridis

(dilator vulvae). According to Meek (1918), in *Phocaena* the erector clitoridis has its origin along most of the lateral margin of the pelvis, with fibers passing ventrally and anteriorly to almost completely surround the corpora cavernosa at their origin. The sphincter vaginae is located just ventral and deep to the erector encircling the neck of the vagina and the urethra. The retractor clitoridis arises from the anterior rectal wall passing anteriorly below the erector clitoridis and the vaginal sphincter to insert along the lateral margin of the insertion of the erector clitoridis. This could be the so-called vaginal band referred to by Slijper (1966).

The urethral orifice lies just dorsal to the clitoridis immediately anterior to the vaginal orifice. The vaginal orifice is itself quite constricted. This might be due to the arrangement of the sphincter vaginae and the retractor clitoridis muscles.

Just past the vaginal orifice the vagina expands to its full diameter some 3 to 4 times the size of the orifice. The surface of the vaginal wall is marked by numerous longitudinal grooves and circular folds. The folds are more prominent anteriorly while the grooves are more prominent in the posterior vagina. There is a deeper groove extending along the posterior midventral wall of the vagina.

There is in *Tursiops* an extensive fold about 2-3 cm anterior to the end of the vagina. This fold, called the pseudocervix, looks so much like the true cervix it can easily be mistaken for it. The opening in the pseudocervix is usually flattened as is the fold itself. There is a chamber called the spermathecal recess formed by the posterior wall of the pseudocervix and the face of the true cervix. In an adult female *Tursiops* this cavity could hold some 6-10 ml of fluid.

It has been suggested that the extremely narrow entrance to the vagina and the spermathecal recess are modifications which help to prevent sea water from washing semen from the vagina after mating has occurred. A recently dissected female *Tursiops* contained 1-2 ml of what appeared to be semen in the vaginal floor just before the pseudocervix while the spermathecal recess contained another 2-3 ml of the same fluid.

The uterus is of the bicornuate type with a short body and long horns. At their vaginal ends the horns are attached along their mesial

surfaces for about the same distances as the length of the body. The horns pass anteriorly for about half their length before turning laterally, ending along the lateral body wall. The ovaries are located just posterior and lateral to the kidneys, held in place by a broad ligament. Each ovary is partially covered by a large well-developed infundibulum continuous with the short, robust uterine tube. There are well-developed fimbria projecting from the uterine tube opening along the inner wall of the infundibulum.

Male Reproductive Organs

The dolphin testes are located in the dorso-lateral abdominal cavity just posterior and lateral to the kidneys. In some species the testes are more caudal and more ventral. The peritoneum associated with each testis forms a short longitudinal mesorchium attaching each organ to the abdominal wall. There is a well-developed gubernaculum which runs from the caudal end of each testis to the pelvic excavation. Each testis is an elongated cylindrical organ covered with a smooth, white tunica vaginalis. There is no cavity of the tunica vaginalis as the tunica vaginalis closely adheres to the thick tough tunica albuginea. When the tunica albuginea is removed, the surface of the organ shows the usual lobular nature of the mammalian testis. The number of lobules is greater than in most other mammalian testes.

There is a well-developed elongated epididymus most often lying in the mesial aspect of the mesorchium. The epididymus is enlarged at the anterior and the posterior ends with the anterior being the larger. Spermatozoan cells leaving each testis pass through a system of 8-12 short vas deferentia which join the anterior finely convoluted epididymus. The epididymi continue posteriorly as the highly convoluted vas deferentia to the verumontanum where they combine for a short distance before entering the urethra. There are, just posterior to the openings from the vas deferentia, one or two openings which lead into a blind tube lying between the terminal ends of the vas deferentia. This blind pouch is called the uterus masculinus or sinus pocularis.

The only accessory genital glands are the prostate glands located on either side of the urethra just behind the verumontanum. This glandular mass is surrounded by a thick layer of striated muscle, the bulbourethral or prostatic compressor. Just after passing between the prostate glands the urethra makes a sharp turn ventrally and anteriorly to enter the body of the penis.

The dolphin penis originates by two crura from the posterior two-thirds of the medial margin of the pelvic bones. These arms fuse to form a single rope-like corpus cavernosum, which extends almost to the end of the penis. There is also a moderately developed corpus cavernosum urethrae. There is no os penis. From the pelvic region the penis runs anteriorly with its distal end projecting into the penial sac.

The skin lining the penial sac is reflected forward to cover the anterior one-third of the penis. This distal part is called the terminal cone. When the penis is erected, the invaginated lining of the penial sac is stretched outward to cover the middle one-third of the penis. Just posterior to the terminal cone the relaxed retracted penis forms an S-shaped loop. This loop is maintained in the flaccid penis by the retractor penis muscles which originate on the anterior rectal wall, and inserts on the ventral penis just back of the terminal cone. An erection of the penis is due partly to the fibro-elastic structure of the organ, partly to turgidity caused by the influx of blood into the cavernous tissue, and partly to relaxation of the retractor muscle.

There is a well-developed ischiocavernosal muscle running from the pelvic bone ventrally and medially, attaching to the ventral crura and to the sheath of the corpus cavernosum. The well-developed bulbocavernosal muscle surrounds the prostate and the base of the corpus cavernosum urethrae.

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3. Dorsocranial view of the cervix and pseudocervix of a female Atlantic bottlenosed dolphin, *Tursiops truncatus*. C = cervix; PS = pseudocervix; and V = vagina.
4. Ventral view of the reproductive organs of a male Atlantic bottlenosed dolphin, *Tursiops truncatus*.

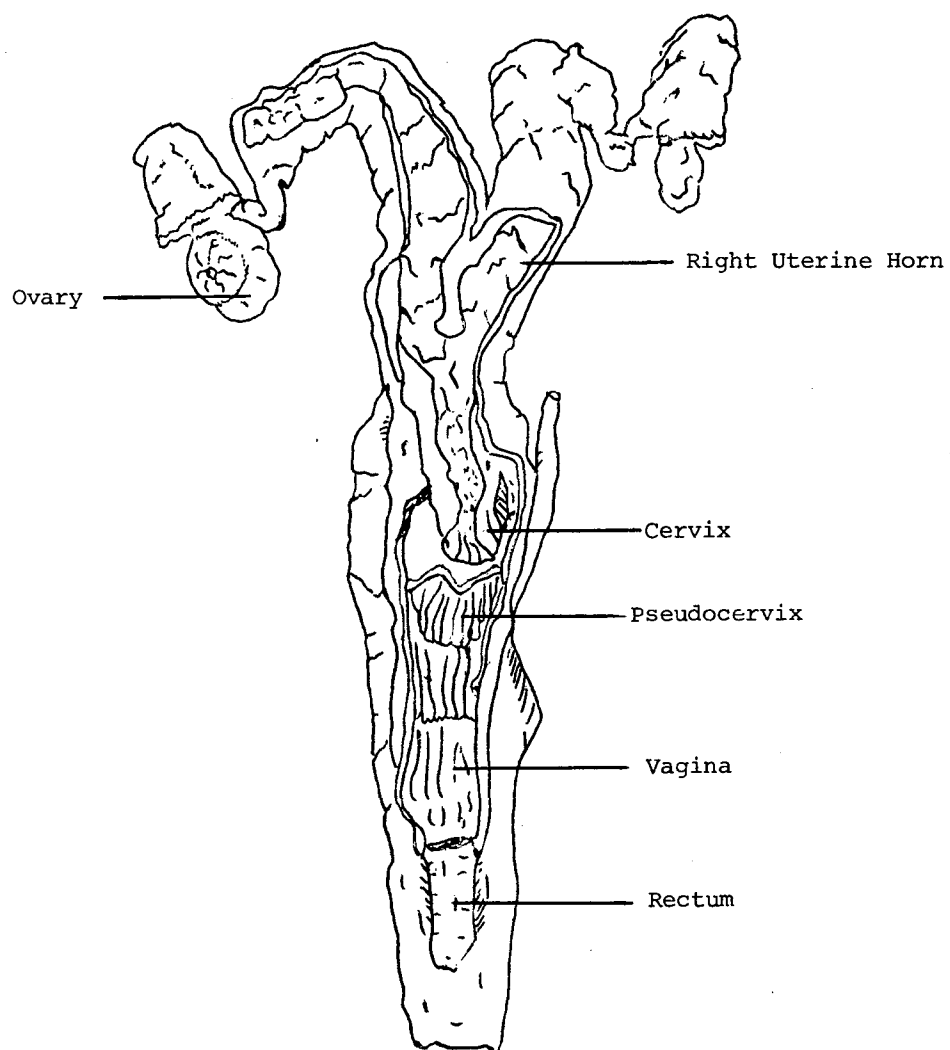


Figure 1



Figure 2

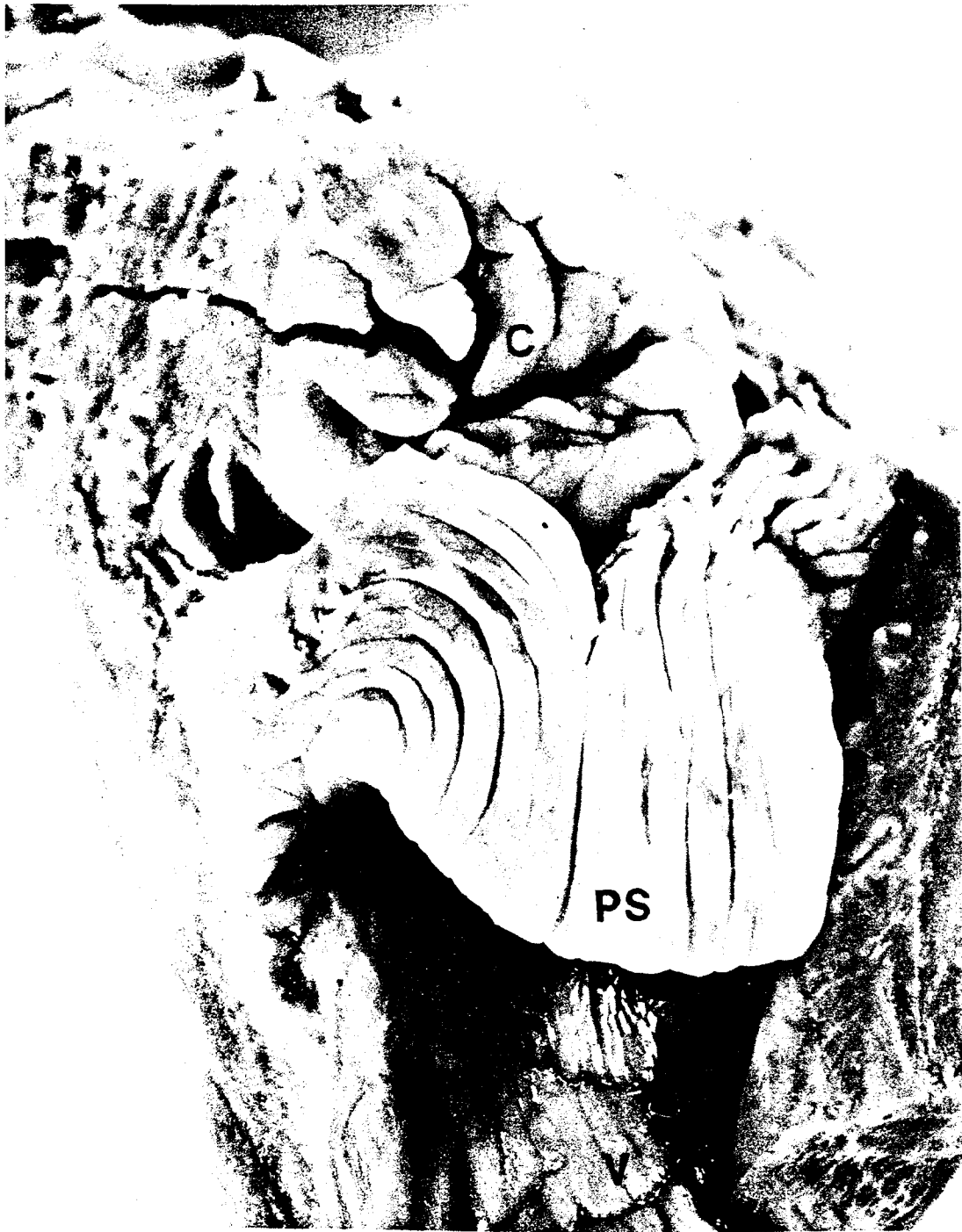


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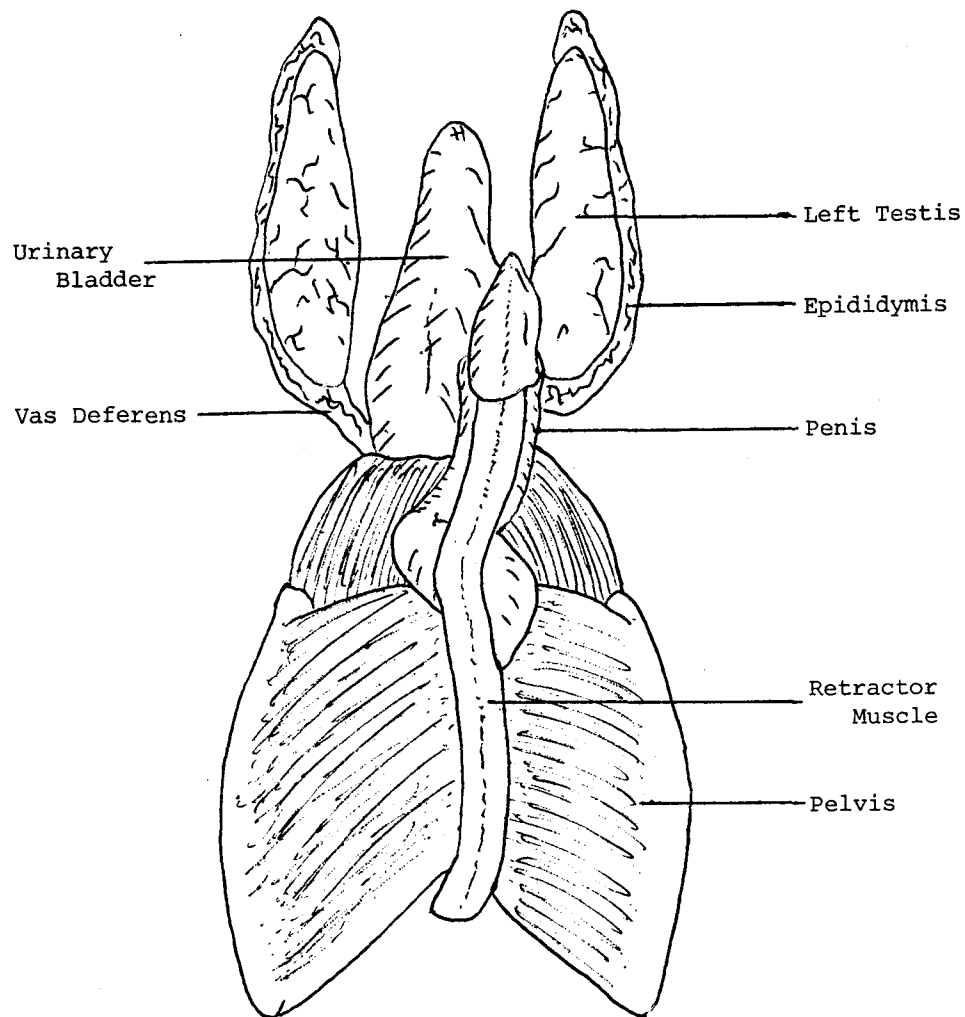


Figure 4

OVARIAN APPEARANCES AND HISTOLOGY
IN *TURSIOPS TRUNCATUS*

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INTRODUCTION

Early reports on the female reproductive organs of *Tursiops truncatus* are lacking in details of ovarian histology and deficient in observations that could give clues as to whether an ovarian cycle exists. Previous literature on ovaries of delphinids has been reviewed by Harrison (1969), Harrison, Boice and Brownell (1969), Harrison and Ridgway (1971). Harrison, Brownell and Boice (1972) have described ovarian appearances in thirty-one female *Tursiops*. An insurmountable difficulty in analyzing ovarian findings is the virtual lack of knowledge of the reproductive history of any small odontocete taken from the wild. Even after a period in captivity there are often insufficient records of mating behaviour and sexual activity, of how long a fertile male has been in the same tank, of length of lactation, to allow useful correlation with ovarian changes. Standard or classical procedures used to investigate reproductive events in laboratory mammals cannot be applied easily to *Tursiops* or other delphinids for obvious reasons.

The ovaries from fifty-two female *Tursiops truncatus* have been examined histologically. They have been weighed, photographed and sliced by hand to determine the size and number of follicles, corpora lutea, corpora albicantia and other structures. Serial sections have been made. Well-fixed tissue has been examined by EM and numerous histochemical tests have been applied to determine the composition of corpora albicantia and other structures.

Most of the females had been caught off Florida and transported to pools in the United States and England where they had survived for periods of as short as a few days to as long as ten years. Others were stranded

animals. Some were pregnant when caught and died either at parturition or some time afterwards. A few are known to have become pregnant in captivity but in virtually every instance critical information about reproductive behaviour is lacking. Details of some of the females in this series are given in Harrison and Ridgway (1971) and Harrison, Brownell and Boice (1972).

The Ovaries

Ovaries of newborn *Tursiops* are 0.5 to 0.8 g in weight and in immature females up to 225 cm in length weigh up to 5.0 g each. They are elongated, smooth-surfaced bodies rolled over along their sides against the central hilar insertion of a short mesovarium containing vessels, nerve bundles and lymphatics. They present on histological examination the usual mammalian cell types. The covering epithelium is low columnar or squamous and lies on a thick tunica albuginea. In late foetal and newborn ovaries the cortex is packed with oocytes 60-80 μ m in diameter surrounded by a single layer of primitive granulosa cells and embedded in stromal tissue. Oocytes situated close to the cortico-medullary junction occasionally show precocious enlargement as do the surrounding follicle elements.

Ovaries of immature females are devoid of large follicles and corpora. There is, however, a marked reduction in the number of oocytes in the cortex over the first and second years of life. The ovaries increase in size due to growth of stromal tissue, increased vascularity and deposition of fibrous tissue. Marked development occurs of small follicles 0.5 to 3.0 mm in diameter but few seem to remain healthy for long. It is difficult to find undeniably healthy follicles in ovaries of immature *Tursiops*: the majority display various stages of atresia. It is important not to confuse atretic follicles reduced to hyalinised fibrous scars with old, shrunken corpora albicantia. The former may be recognized by their size, by the remnants of a collapsed zona pellucida and by the presence of degenerate theca interna cells about the periphery. In rare instances the granulosa cells degenerate rapidly and leave the collapsed follicle full of thecal cells and vascular elements; such a structure

has been called a corpus atreticum. The theca interna cells of *Tursiops*, and other delphinids, do not appear to give rise to secondary interstitial cells as can occur in some other mammals. Indeed, no elements with characteristics of interstitial cells have been identified with certainty in *Tursiops* either in foetal specimens (as found in phocid and equine ovaries) or in adult ovaries.

The growing follicles resemble those of most other mammalian types but there are often Call-Exner spaces in the membrane granulosa, the theca interna is well developed and vascularized, a thecal cone is usually present. Polyovular follicles have not been seen but multinuclear oocytes, usually degenerate, are not uncommon.

The length of females at sexual maturity shows much variation; this could be related to characteristics of the population, nutrition and endocrine factors as well as to individual variation. Several observations suggest that the final pre-ovulatory growth phase of a follicle is rapid and that ovulation is probably induced. It is tempting to argue that ovulation occurs only when the internal and external environment are at optimal or particular conditions. The ovaries of many females in captivity are inactive despite observations of alleged mating behaviour. On the other hand, several trained females have become pregnant although the circumstances of the conceptions have never been adequately recorded. The ovaries of a few females do, however, exhibit a rather greater number of corpora albicantia than might reasonably be related to pregnancies. It will be shown that these "extra" corpora albicantia could be derived from sources other than corpora lutea of pregnancy, even so they could also be derived from corpora lutea of a succession of infertile cycles.

Corpora Lutea and Corpora Albicantia

The corpus luteum of *Tursiops* is a compact gland, subdivided into lobules by fibrous septa containing large blood vessels. It is often more or less pedunculated but seldom has a central cavity. Corpora lutea of pregnancy are from 25 to 32 mm in greatest diameter. They persist until term when the luteal cells show much vacuolation and shrinkage.

In this series a corpus luteum was found only in pregnant females or in ones that had recently aborted or given birth prematurely, but this does not exclude the possibility of pseudopregnancy.

Corpora lutea in mammals are known to be of several types (Harrison and Weir, 1976):

- 1) Corpus luteum of the cycle
- 2) Corpus luteum of delayed implantation
- 3) Corpus luteum of pregnancy
- 4) Secondary corpus luteum of pregnancy
- 5) Corpus luteum of pseudopregnancy
- 6) Accessory corpus luteum or luteal body
- 7) Aberrant corpus luteum (persistent form of 1)
- 8) Corpus atreticum

Of these, numbers 3, 4, 6 and 8 have been found in the *Tursiops* of this series; numbers 1 and 5 may well occur but no proof is available. All of these types (except 8, about the fate of which little is known) can presumably retrogress to form a corpus albicans that persists for a variable length of time depending on the species. In cetaceans the corpus albicans persists for a long time, shrinking as it ages, but there is as yet no definite proof that all corpora albicantia persist for the life of any female (Harrison, 1949, 1969).

Corpora albicantia in *Tursiops* vary in shape and size and in their histological features. They present as rounded protuberances from the body of the ovary, as pedunculated masses joined to the ovary by stalks of varying thickness, as conical papillae projecting from the ovarian surface, as surface plaques and as scars like a cicatrix with a wrinkled surface. Histologically they display varying degrees of cellularity, of the degree of degeneration of those cells remaining, of persistence of fibrous septa and of advancing obliteration of the blood vessels. Few leucocytes and histocytes are present. The principal feature, however, is the deposition of a hyaline material in place of the luteal tissue. This degenerative process appears to begin within weeks of parturition and possibly even earlier. Pigment granules and glycoproteins are also present. Electron microscopy reveals bundles of collagenous fibers,

granules and vesicles of various types embedded in the amorphous matrix, as well as degenerated remnants of luteal elements. Even in corpora albicantia aged at least several years a few small sinusoids contain intact red cells and have a recognizable tunica intima. Intact smooth muscle cells are also present in the tunica media of large vessels.

Several suggestions have been made to explain the persistence of corpora albicantia in cetaceans (Dempsey and Wislocki, 1941; Harrison, Brownell and Boice, 1972). These involve or could involve:

- 1) Inadequate blood supply to the corpus luteum after the gland had become fully developed.
- 2) Sudden collapse of luteal circulation early on during regression, and an associated obliterative endarteritis.
- 3) A marked lack of leucocytes and phagocytic histiocytes.
- 4) Absence of luteolytic enzyme systems.
- 5) Lack of, or reduced action of prostaglandins.
- 6) Continued low threshold hypophyseal luteotrophic activity during and after lactation.

In several odontocetes, the left ovary is often larger than the right and contains either all or the majority of the corpora albicantia (Slijper, 1949; Harrison, Boice and Brownell, 1969). Ohsumi (1964) placed *Tursiops* in his Type III of "accumulation curves" in cetacean ovaries. He maintained that for a time ovulation occurred only from the left ovary but that then the right ovary became active and acquired more corpora than the left. Harrison and Ridgway (1971) were unable to confirm this claim. In this extended series, eleven females had corpora in only the left ovary, six had corpora in only the right ovary, and eight had corpora in both ovaries. Altogether there were 74 corpora in the left and 53 in the right ovary.

Ovaries of one adult *Tursiops* will be described in detail. This female was caught in August 1971, became pregnant in captivity, probably in January-February 1972, and died in labour in January 1973. The length at death was 235 cm, weight 176 kg. The number of corpora and their diameters in millimeters are as follows:

<u>Left Ovary</u> (16.5 g)	<u>Right Ovary</u> (3.7 g)
Corp. lut. 31 x 30 x 24 (mm)	Corp. alb. 1) 9 x 9 x 5
Acc. corp. lut. 12 x 10 x 6	2) 11 x 8 x 5
Corp. alb. 1) 12 x 10 x 8	3) 10 x 8 x 5
2) 16 x 9 x 6	4) 4 x 3 x 3
3) 6 x 3 x 3	5) 3 x 3 x 3
	6) 5 x 4 x 4
	7) 3 x 2 x 2
	8) 3 x 2 x 2
	Corp. atret. 14 x 7 x 5

An analysis of the corpora in this animal will be made in relation to those of others in the series (Figures 1, 2, 3). This shows it to be unlikely that each corpus albicans represents a corpus luteum of pregnancy. While a number of models of reproductive patterns in *Tursiops* can be constructed by computer, making assumptions based on information in this report, there is an essential need for further research.

FURTHER RESEARCH

A study of ovarian appearances and histological features indicates a need for research on a number of important aspects of reproduction in *Tursiops*:

- 1) What factors determine the age at reaching sexual maturity? Why is ovarian activity inhibited in some females of a length and alleged age which ought to be compatible with reproductive activity? Why do some females exhibit sexual response when the ovaries are apparently inactive?
- 2) Is ovulation always induced or can it occur spontaneously, and if so, under what circumstances? In other words, is *Tursiops* always monoestrous? If it can exhibit a polyoestrous state, how can the ovarian cycle be followed?
- 3) Follicle development appears to be rapid: what factors control follicular growth and activity? Does post-partum ovulation occur regularly, does it occur only after death of a neonate, loss of a premature calf or after an abortion? What effect does lactation, especially if prolonged, have on follicular growth and ovulation?

- 4) What types of corpus luteum or lutealized follicle can form a corpus albicans? How can one type and age form a particular corpus albicans? Do all corpora albicantia persist, do they retrogress at a constant rate, what factors cause them to shrink?
- 5) There is to date no evidence of delayed implantation in *Tursiops* but nothing is known about implantation in any delphinid, nor about the incidence of failure of implantation, pseudopregnancy, and early abortion.
- 6) Accessory or secondary corpora lutea have been described in several delphinid species: are those in *Tursiops* related to mating during pregnancy?

While valuable information can be gleaned from the study of occasional specimens with a known history, from breeding stocks held in tanks and from animals "passing through" an institution, it would seem that real advances will come only when it is possible to investigate a large collection of *Tursiops* kept under optimal conditions primarily for the study of reproduction.

It must be emphasized that little of the material described here could have become available without the help of many institutions and their staff: all are thanked most warmly. Grateful thanks are also expressed to D.A. McBrearty and Mrs. G.A. King for technical help.

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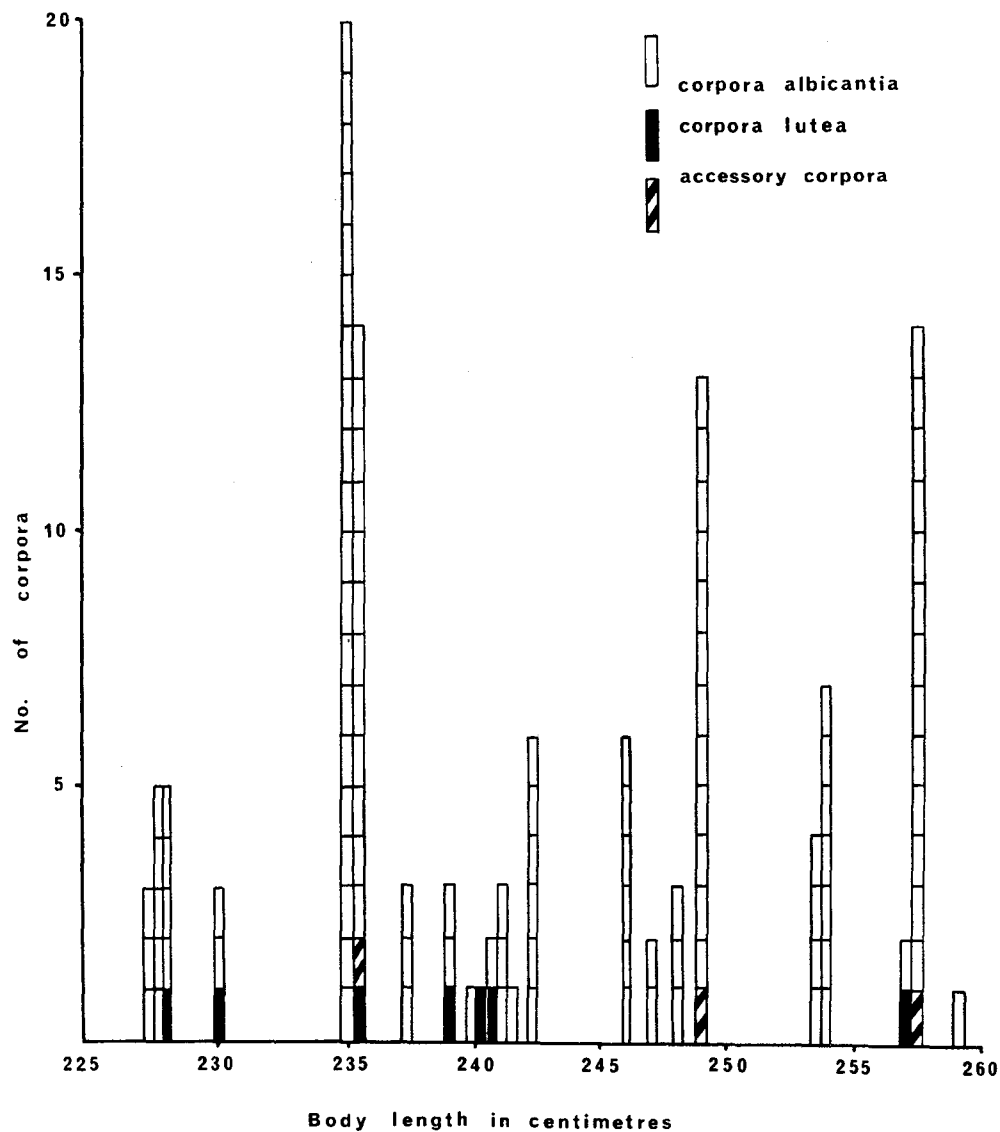


Fig. 1.
Diagram showing the number of corpora lutea (primary and secondary, or accessory), and corpora albicantia in a series of adult female *Tursiops truncatus* 228-259 cm in length. All except four of the females had been caught off Florida and had been in captivity for varying periods (days to years) either in the U.S. or in England. Some were pregnant when caught and gave birth in captivity, a few conceived and gave birth in captivity. Some details of the time over which a female was in a tank with a fertile male is known for five animals but certain information of a critical nature is lacking for virtually all females.

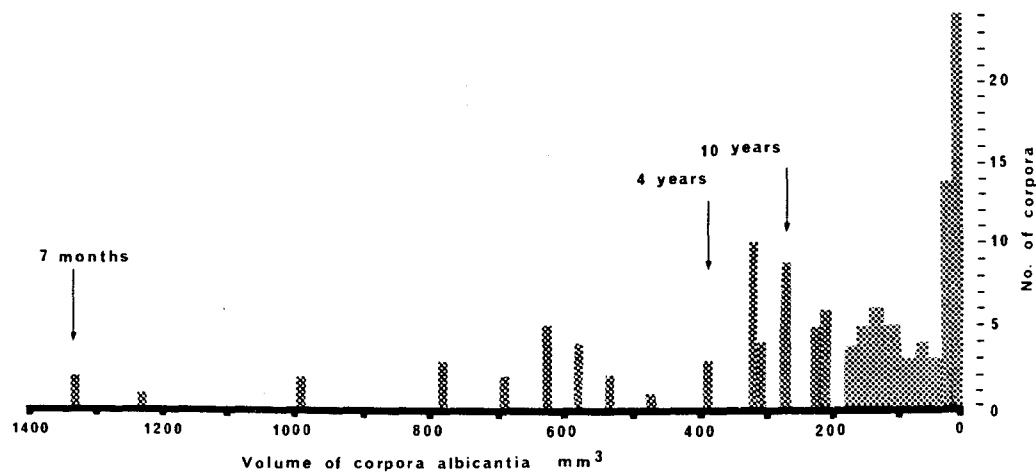


Fig. 2. Diagram to indicate the number of corpora albicantia of different volumes (mm^3) in all the ovaries of the females in Fig. 1. The arrows point to corpora albicantia believed to be associated with a previous known pregnancy.

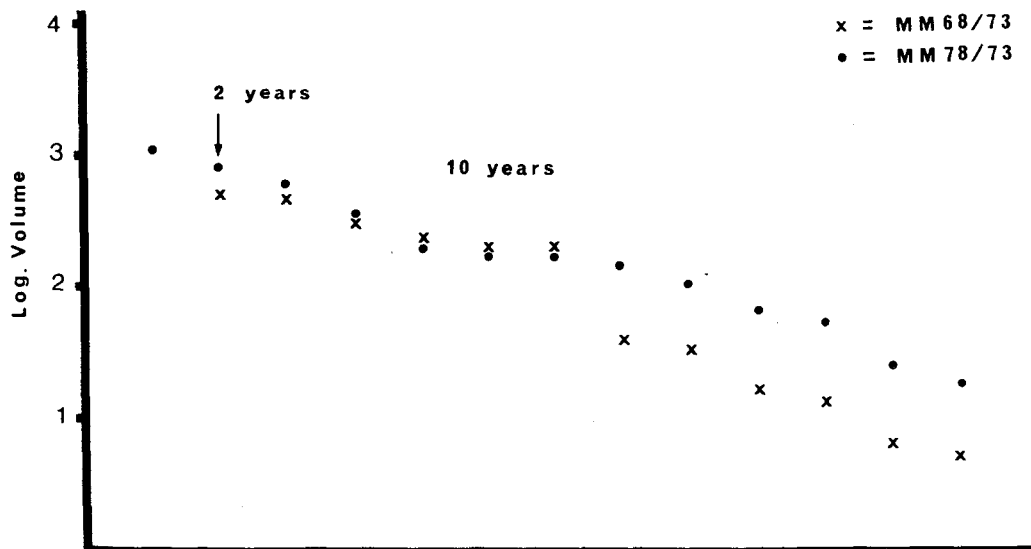


Fig. 3. Diagram to show the logarithm of the volume (mm^3) of the corpora albicantia in the ovaries of two adult *Tursiops*. There were 13 corpora albicantia in one female (MM78) the largest of which was about 10 months old and related to a known birth. The second female (MM68) died in labour and the largest corpus albicans can be argued to be at least two years old. The corpora have been spaced out at equal intervals on the assumption that the smallest are the oldest.

COLLECTION AND STORAGE OF SEMEN FROM DOLPHINS

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INTRODUCTION

In 1952, Polge described techniques for freezing bull semen while maintaining its fertilization capability (Polge, 1952). He found that when water in the cell is replaced by glycerine, the cell can be subjected to ultra sub-zero temperatures and there remain in "suspended animation" for extended periods of time. This amazing technique of preserving the male germ cell, *ad infinitum*, with its precious chromosome-gene complement intact, was to benefit immeasurably the sciences of reproduction genetics and cell biology the world over. Two decades later the dollar value to the meat and milk industries alone is astronomical. This technique has been improved upon only slightly and is now being called upon to assist man in delaying the inevitable extinction of certain co-residents on earth.

Spermatozoa have been extracted from their various sources by several techniques: by allowing natural mating followed by siphoning the contents of the vaginal vault; by manual massage of the penis and/or the secondary sex organs; by the roguish enticement of the artificial vagina; by application of controlled electrical impulses in both the living and the dead animal; and by paracentesis of the sperm cell reservoirs.

The mechanics and physical processes of dividing the total numbers of living spermatozoa available into "fertilizing doses" for freeze processing has been modified by ingenuity and economics. For a number of years the medicinal 1 or 2 cc glass ampule was the universal container. However, a simple principle of physics - that fluids adhere to surfaces - pointed up a costly waste of sperm cells carried in that very fluid that was being discarded with the ampule.

Modern techniques demand that essentially every surviving spermatozoa be made available for deposition into the female. The basis for the modern container is a unique application of the familiar soda straw. One end of the lumen is closed with a non-toxic paste. The fluid semen, extended in certain formulae, is injected into the straw and a second plug is used to seal the tube. The contents are then frozen, and stored, in ultra sub-zero temperatures.

During insemination, the straw is removed from its cold storage environment, thawed quickly, and the contents ejected into the female by simply cutting off the paste seal, thus opening the lumen, and using the other end as a plunger in a syringe. Essentially the entire volume of sperm-laden fluid is thus transferred to the female.

A technique assuring even greater efficiency was developed by Japanese workers wherein the spermatozoa are suspended in certain extenders and the mixture dropped directly onto dry ice or into liquid nitrogen. The result is an aspirin-sized pellet of frozen spermatozoa--and they may be stored just that way.

These pellets may be thawed outside the female and inseminated with syringe and pipette or the pellet itself can be deposited in the female reproductive tract. The economical advantages relating to long time storage of these simple items versus the bulky, fragile glass ampule are obvious.

With such techniques available, it is a challenge to researchers to adapt processes for handling germ cells, of both male and female, of endangered species.

The captive natural breeding of dolphins offers several advantages over capture of individuals at sea. Although there are the obvious economic benefits, as well as conservation of wild stocks, there are other considerations as well. Diseased animals are not introduced into a "clean" facility and human contact can be made early in the life of the animal, facilitating later handling and training.

Application of artificial insemination techniques to dolphin breeding offers many additional benefits. Aquariums without sexually mature breeding males can obtain semen from other institutions. Behavioral problems

with very aggressive males, possibly causing harm to females, can be eliminated. Nonreceptive females, which do not seem to be interested in reproductive behavior, can be inseminated artificially. The logistics of moving animals to larger holding areas more conducive to sexual activity are eliminated. More exotic cetacean species, which are even less likely to breed naturally in captivity, could be inseminated by using the basic techniques developed for *Tursiops*. The experiment described was conducted to collect semen from a dolphin, grossly characterize the specimen, and judge its freezing potential.

PROCEDURE AND RESULTS

A male Atlantic bottlenosed dolphin (*Tursiops truncatus*) about 15 years old and weighing about 180 kg was immobilized by draining the water from his residence tank. Heavy foam padding was used to protect him during the manipulations.

An attempt was made to collect semen from the animal by electrical stimulation of the area of the penis and accessory sex glands by placing a probe in the rectum immediately adjacent to these organs. The probe consisted of a hard rubber core about 2 cm in diameter and 32 cm long with 4 circular metal contacts along the distal length at about 2.5 cm intervals. Rhythmic electrical stimuli were delivered to the electrodes from a transistorized power pack* which developed a maximum of 12 volts, and a very low milliamperage at about 20 cycles per second. This unit is a popular power source for electrical ejaculation of bulls, rams, and billies. After several unsuccessful trials, a massage of the secondary sex glands per rectum using the gloved finger of the technician was attempted.

Although no ejaculation occurred visibly during the actual electrical stimulation or during the digital massage, semen was emitted when a third maneuver was imposed upon the animal. The tips of the gloved fingers were inserted along the genital slit and the distal portion of the penis was gently massaged. Within 3 to 5 minutes an opaque, white, free-flowing fluid was observed. About 0.5 cc was collected as it flowed down the genital slit while a smaller portion was lost.

*Standard Precision Electronics, Denver, Colorado.

One might conjecture whether or not the prior stimulation per rectum influenced the effect of the finger massage of the penis itself, however, it is reported that ejaculation does occur in male dolphins with only a slight amount of penile stimulation.

The semen sample was evaluated using four characteristics: concentration, degree of vigor, percent living cells, and morphology according to an accepted system of classification of bull semen (Hill, unpublished).

Gross examination and microscopic evaluation showed the sample was "very concentrated" thus having an estimated sperm cell count of 1 to 1 1/2 billion per cc. "Degree of vigor" was rated the highest of four grades indicating that more than 75% of the cells exhibited normal, progressive motion. Using an eosin-nigrosin stain to distinguish living from dead spermatozoa, 90% or more of the cells were alive when the dyes contacted the sample smear. "Morphology" studies indicated there were less than 10% primary and less than 20% secondary abnormalities in the ejaculate.

In general, it could be said that the semen sample studied resembled an "excellent" sample of ram's semen. Due to limits of time and material, no attempt was made to freeze process this ejaculate although all characteristics indicate that the spermatozoa would survive the rigors of ultra sub-zero temperatures as satisfactorily as ram or bull semen.

DISCUSSION

There seems little doubt that semen can be obtained from certain individual dolphins. Whether or not the males produce mature living spermatozoa in a cyclic pattern is still conjecture. Some important aspects of spermatogenesis should be investigated methodically. This could be done by collecting semen at regular intervals throughout the year and subjecting these samples to a standardized evaluation system. It may be possible to determine changes in the size of the testes throughout the year by using ultrasonics. Testicular biopsy techniques could also be investigated.

In any event, it would appear that physical insemination of the female would not present insurmountable problems. There appears to be a pseudo cervix just posterior to the true cervix which probably acts as a

reflux barrier, minimizing the amount of the ejaculated fluids which escape during copulation.

This was obvious on a recent dissection of the reproductive tract of a beached female Pacific bottlenosed dolphin (Green, 1975, unpublished). Semen was found just posterior to the pseudo cervix and between this structure and the true cervix. For artificial insemination it would probably suffice to deposit the semen sample by means of syringe and pipette just anterior to the muscular fold of the pseudo cervix.

As with many species of mammals, however, the real problem involves determination of the period of time when the female is producing viable ova. Granted that the male does produce sperm cells at a more efficient rate during certain periods of rut, then is the female also limited to such periods of ovulation? Is there an increase in the activity of the ovaries as is described for the male counterpart? Is it possible to measure the changes in size of the ovaries and uterus with ultrasonography? Can ovulation be induced predictably for experimentation with artificial insemination procedures or might it be necessary in the absence of reliable hormone data to use scheduled artificial insemination procedures to determine time of ovulation? Other questions which prove intriguing and should be resolved are: Will the female copulate at times other than when a receptive ovum is present? How many living spermatozoa are necessary to create a "sperm cover" to insure fertilization? Does sea water adversely effect spermatozoa? Or is it necessary for successful fertilization?

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DIAGNOSIS OF PREGNANCY IN SMALL CETACEANS WITH
DOPPLER SONOGRAPHY AND OTHER TECHNIQUES

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INTRODUCTION

Until recently, diagnosing pregnancy in *Tursiops* has been based on the observation that abdominal swelling, mammary enlargement, and vaginal dilation usually lead to the appearance of a fetus. Observers were sometimes able to identify pregnancy as early as at 6 months of gestation but there was always a lack of certainty. Various electronic devices developed for human medicine have now been successfully adapted for use with *Tursiops*, enabling us to make the diagnosis somewhat earlier than by standard morphologic observations. In addition, it is now possible to detect intrauterine fetal viability.

PREGNANCY DIAGNOSIS

Continuous Acoustic Energy Ultrasound (Doppler), (Brown, 1975).

The obstetrical Doppler operates on a frequency around 2.25 MHz. An ultrasonic beam is transmitted and the returning sound received by separate crystals within a transducer. The frequency of sound when reflected from a moving object, e.g., red blood cells, varies with the velocity of the object, producing an audible response in the Doppler unit. When the beam is directed toward the fetal heart or great arteries the sound produced reflects the fetal heart beat which is considerably more rapid than that of the mother (roughly 140 beats/minute compared to 60-80 beats/minute in the adult).

Since *Tursiops* most frequently exhibit left uterine horn pregnancies, examination is performed with the animal placed onto her right side. The Doppler transducer is placed upon the mid-abdominal area. By directing the sound beam in various directions, the fetal heart beat, if present, can be found.

The ultrasound technique has been free of adverse side effects. The procedure requires only a few minutes to perform, necessitating minimal stress to the animal. The unit has the additional advantage of being compact and portable. Using the Doppler, numerous *Tursiops* pregnancies have been diagnosed early in the second trimester of gestation.

Pulsing Acoustic Energy Ultrasound, (Brown, 1975).

This technique operates using intermittent pulses of ultrasound from a transducer crystal. The return signal from tissue density interfaces is received by the same crystal, creating an electrical current which is then amplified and put into a video display.

1. A-mode (amplitude modulated signal) and M-mode (time motion mode) - When the transducers are held stationary, tissue interfaces are exhibited in a single plane (A-mode). By providing a moving recorded, tissues or organs which move may be visualized (M-mode). The beating heart of the fetus can be recorded by this technique.

2. B-scan - With a mobile transducer, a two-dimensional, cross-sectional picture of the structure, similar to a radar image, is produced. Masses such as a pregnant uterus and fetus are easily visualized using this technique.

The pulsing ultrasound procedures are free of adverse side effects. Only a few minutes are required but considerable instrumentation is necessary.

Although few *Tursiops* pregnancy diagnoses have been performed using the pulsing ultrasound technique, the method has the capability of detecting pregnancy within the first trimester of gestation (see Leopold, this volume).

Radiography

By using standard radiographic techniques, ossification of the fetal spine and skull may be detected early within the second trimester of gestation.

The use of X-rays carries with it danger of X-irradiation to tissue, particularly organs exhibiting rapid cellular production, especially in the developing fetus. The technique requires rather bulky and expensive

equipment. Considerable time in animal handling and restraint are also necessary.

Morphology

As the fetus grows and develops, certain conformational changes occur in the cow which are highly suggestive of pregnancy.

1. Body conformation - By the mid second trimester of gestation, there is apparent enlargement of the abdominal girth. Visible swelling is present at the mammary glands, and occasionally the nipples protrude from their crypts. In the third trimester dilatation of vaginal tissues becomes apparent.

2. Ballotment - Early in the third trimester of gestation, the fetus may be balloted against the abdominal wall by performing short firm pushing motions against the belly.

3. Fetal movement - Late in the second trimester of gestation fetal movements are seen if the cow is held under minimal physical restraint on her right side.

DETERMINATION OF FETAL VIABILITY

Once pregnancy has been confirmed, determining fetal viability is important, particularly in late gestation. At this stage the majority of intrauterine fetal mortalities occur, and the presence of a live fetus plays a major role in parturition. If a cow in late gestation is exhibiting signs of illness, it is imperative to determine the presence of a dead fetus before a clinical course is established.

Continuous Acoustic Energy Ultrasound (Doppler), (Brown, 1975).

The absence of an audible fetal heart sound with the Doppler following a complete survey of both sides of the cow's abdomen is diagnostic of fetal death. With animals that are very large, *e.g.*, *Tursiops gilli* and small whales, a negative Doppler signal must be considered with reference to the ease with which the maternal acoustic sounds are heard.

Pulsing Acoustic Energy Ultrasound (M-mode), (Brown, 1975).

The absence of a fetal heart-motion scan is diagnostic of fetal death. Again, a complete survey of the abdomen is necessary. In large

animals, a reduction of sound frequency may be necessary to provide the depth of penetration sufficient to reach the fetal heart.

Electrocardiogram

Electrodes placed on or into the cow do not receive ECG's from the fetus. If one wishes to obtain an ECG from the fetus, the electrodes must be inserted into the fetus itself. Long needles with the ECG leads fixed within their lumen may be directed through the left abdominal wall of the cow into the fetus. Because of great risk of trauma to the fetus and because better methods are available for *Tursiops*, this technique should be reserved for the larger cetaceans and then used only when other methods have failed.

Fetal Movement

The absence of fetal movement is suggestive of, but not diagnostic of, fetal death. An abnormally quiet fetus late in gestation may be indicative of fetal ill-health.

Analysis of Amniotic Fluid

Amniotic fluid may be obtained from a *Tursiops* in the third trimester of gestation via amniocentesis either by puncture through the cow's abdominal wall (left side) or through a needle directed vaginally through the cervix. Because of restraint problems and the probable irritation to the cervix and the cervical mucous plug, the latter approach is not recommended.

1. Color - Normal amniotic fluid is clear, non-viscous, and non-fetid. Following fetal death, the fluid turns brown, and if bacterial contamination occurs it may become viscous and fetid (Brenner, 1975).

2. Cytology - The normal amniotic fluid of *Tursiops* contains no leukocytes or red blood cells. With fetal death, both red and white blood cells permeate the fluid as the fetus undergoes autolysis and decomposition. The leukocytes are visible on a wet smear of amniotic fluid stained with one drop of New Methylene Blue Stain^a under 400X magnification. Red blood cells are also seen in such preparation but do not take up the stain.

^aMedical Chemical Inc., Santa Monica, CA 20404

3. pH - The normal amniotic fluid of the rhesus monkey has a slightly alkaline pH (roughly 7.4) (Seeds, 1972). When the fetus dies, amniotic fluid pCO_2 rises, bicarbonate drops and pH drops. If amniotic fluid shifts into an acid pH, this is strongly suggestive of fetal death.

4. Estriol - Rhesus monkeys contain measurable levels of estrogenic hormones (mostly estriol) in the normal amniotic fluid. The hormone increases in concentration as parturition approaches. The presence of a viable fetus plays an important feedback role in maintaining this estrogen rise from the ovaries and fetus. If the fetus dies, the feedback link is broken and estrogenic hormones quickly disappear from the amniotic fluid (Brenner, 1975). The absence of these hormones is indicative of fetal death if the amniocentesis is performed late in gestation.

In order to provide proper husbandry care for the expectant *Tursiops* cow and ultimately for her infant calf, an accurate diagnosis of the pregnancy must be made early enough in gestation to allow for any adjustments or possible moves should they be necessary, before there is a significant risk to either animal's life. This paper describes the several electronic devices which may be used practically for such a diagnosis early in the second trimester of gestation; there are no techniques used at the present time which will consistently provide an earlier diagnosis. Similarly, there are several methods available for the practical determination of fetal viability. Most of the methods are easily carried out with minimal stress to the cow and fetus.

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ROLE OF DIAGNOSTIC ULTRASOUND IN EVALUATING
PREGNANCY IN *TURSIOPS TRUNCATUS*

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INTRODUCTION

Diagnostic ultrasound has proven of great benefit in the evaluation of both normal and abnormal human pregnancies. Since its initial usage for these purposes by Donald in Scotland in the early 1950's, technological improvements have occurred that have rendered it commonplace in obstetrical practice today. The technique has the significant advantage over radiological methods of investigation in that it uses reflected ultrasound waves which are non-ionizing to produce its images. To date, no damage to mother or fetus has been reported with even prolonged clinical exposure. It may therefore be used serially, thereby providing an additional dimension of information which has often been difficult to obtain by any other means.

By employing this technique, human pregnancy may be imaged as early as four weeks post conception without fear of injury. As the pregnancy develops, placental site and morphology are clearly discernible. The growing fetus is also clearly visible. Although earlier work has been pointed at simply determining gestational age from this information, it is now apparent that a great deal of information regarding fetal physiology and malformations may be detected.

Until recently, the usual means of ultrasound imaging employed a single piezoelectric transducer which served as both a sender of the basic 2.25 MHz pulse and a receiver of the echoes reflected from the interior of the uterus. By manually moving the transducer over the uterus in a preselected plane, the reflected echo pattern was amalgamated through a set of potentiometers into a static image. By processing this information through a television scan converter, exceptionally high resolution

"gray scale" static images of the fetal anatomy may be produced. This equipment is generally large and has not readily been adaptable to animal experiments.

Recently a newer, more portable type of ultrasonic device has been introduced for use in obstetrics. This instrument utilizes an array of transducers, rather than a single one, and individual elements are pulsed sequentially in rapid fashion to produce what appears to be a continuous "real time" image. The complex transducer is simply placed on the maternal abdomen and does not require the complex transducer movements. While this technique produces pictures of lower resolution, it does permit visualization of the dynamic events of human pregnancy. Fetal motions of all sorts can be visualized. Fetal cardiac action, aortic pulsations, intracranial pulsations and respiration can usually be readily appreciated.

The Division of Ultrasound, Department of Radiology of UCSD was privileged to participate in the early clinical evaluation of the latter type of ultrasound unit, manufactured by the Advanced Diagnostic Research Company of Tempe, Arizona.

METHODS AND RESULTS

Because of the suitability of the real time instrumentation, it was surmised that it might be of benefit in the study of dolphins as well as other animals. Accordingly, studies of two adult *Tursiops truncatus* were performed to determine the feasibility of such studies. The first of these, at Sea World, San Diego, was performed on a pregnant female animal. Visualization of the oscilloscopic screen was rendered difficult by the ambient light, but sporadic movements of the calf and the maternal diaphragm were believed to be detected. Videotape to record these movements was not available at this time. The second study, performed at the Naval Undersea Center, San Diego, was performed indoors on a male animal with videotape facilities available. On this occasion visualization was much more successful, with reasonable demonstration of the diaphragmatic motion, liver, and cardiac action. Some internal structure was also visualized when the instrument was placed over the melon of the animal.

Although imaging at no time approached the excellence to which we are accustomed in the human fetus, the results seem promising enough to warrant continued study in this area.

RECOMMENDATIONS

There are a number of factors which combine to make the current type of study difficult with the commercially available equipment employed here.

First, a waterproof array of transducers that could be taken into the tank with the animal would prove to be of great benefit. The current technique which necessitates removal of the animal from the tank seems to impose an unnecessary risk on the animal.

The second factor related to the thickness of blubber of the animal. In the human the 2.25 MHz frequency provides adequate penetration of the proximal 10-15 cm of the uterus since it is relatively subcutaneous in location. In the dolphin, the thickness of this tissue and the relatively greater distances involved make penetration difficult. By employing a lower frequency, e.g., 1 MHz, considerably improved penetration could be achieved. This would, however, be accompanied by some loss of resolution.

A third improvement would be the use of an instrument within an expanded depth of field to permit display of these deeper structures.

Given these modifications, this device might readily prove to be a valuable adjunct to the study of dolphin pregnancy.

DOLPHIN REPRODUCTION:
NUTRITIONAL CONSIDERATIONS

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INTRODUCTION

The recurring theme throughout this workshop focuses on our uncertain knowledge of dolphin reproduction. We needn't feel exclusive in this regard, as the literature on other animals, including the domesticated species, is really rather sparing. More is known about humans, of course, and yet a recent compendium published by the Committee on Maternal Nutrition of the National Academy of Sciences (1970) points out the many controversial issues and offers considerable recommendations for research. Unfortunately, much of what is known is not applicable to dolphins, at least not in a way that can be assessed using practical experimental techniques. Moreover, there is always an inherent danger in extrapolating data from laboratory animals and applying it to dolphins; there are obvious differences in physiology, environment, and diet, and the increase in nutrient requirements of smaller laboratory species during gestation are proportionately greater because they carry a relatively larger weight of young (Leitch et al., 1959).

This communication is a modest attempt to place nutrition into some reasonable perspective in the context of reproduction; to examine our knowledge of its role in other species; to point out what might be special requirements of captive dolphins; and to make broad recommendations for feeding and for future research.

NUTRITION IN PERSPECTIVE

Nutrient requirements are in a dynamic state, always reflecting changing metabolic demands. Reproduction is only one of these demands, yet it is inextricably linked with the whole chain of life sustaining

energy-costing factors. The total cost of pregnancy to a dolphin can be calculated as the sum of the energy of the conceptus plus that of the mother for the duration of pregnancy. The cost value ascribed to her alone is not the same as was her pregravid energy cost. Fetal development is accompanied by extensive changes in maternal body composition and metabolism, all of which increase her basal cost. In addition, her day to day requirements depend on her age, growing animals, of course, requiring more energy; her state of activity, and therefore her show schedule; environmental stresses, of which there are many in captivity; and, of course, disease. The arithmetic is far from simple.

Now let us view nutrition from a standpoint other than its broad influence on the mother and conceptus or neonate. What are the patterns of reproductive casualties, and where can nutrition be sensibly considered.

In man, there is an intrinsic handicap experienced by the male fetus and the male infant. The same trend seems to exist in *Tursiops*. It is still a puzzle in man, as it certainly is in the dolphin, but it is unlikely that maternal nutrition features prominently in the cause.

Also in man, maternal age is a biological determinant of reproductive efficiency. Fetal mortality is elevated among girls 17 years of age and under, then rises again sharply after age 29. Death rate in infants born to mothers 15 years and under is twice as high as in the 20 year old group. Young, perhaps immature pregravid dolphins seem to be paralleling the human experience. Their reproductive success is particularly bad, and here there is room for nutritional considerations. A growing subadult pregnant female may be competing with the developing fetus for nutrients, and such animals would be particularly vulnerable to the ill effects of food deprivation or so called motivational inducement (Casida, 1959; Chow and Lee, 1964).

Until we know more about the patterns of reproductive casualties in dolphins, it will be difficult to accurately assess the role of nutrition. As a broad guideline, the key to nutritional involvement is likely related to the time of the casualty. Early neonatal deaths are

usually related to the same factors which lead to fetal deaths, nutrition among them. Late or postneonatal mortality is more likely to be associated with environmental and behavioral factors, and to disease.

NUTRITION AND THE GRAVID FEMALE

Pregnancy is associated with extensive changes in maternal body composition and metabolism. The changes can be quantified, their net effect(s) on the female is varied, and their influence on nutrient requirements is critically debated.

In women, pregnancy is associated with protein shifts, an increase in some plasma enzymes, changes in blood flow patterns, a high rate of water loss early in pregnancy followed by a later increase in total body water retention. Hytten and Thomson (1970) have critically reviewed these changes. There is an increased renal loss of folate which may predispose to megaloblastic anemia. There is an increase in total red cell mass which is masked by a disproportionately greater plasma volume retention, giving the appearance of anemia. The most obvious sign of pregnancy is, of course, weight gain, especially during the third trimester, and this is necessarily tied in with increased appetite.

The need for an increase in selective nutrients during this time is still in question. Clearly, there is an increased energy demand which is met by increasing caloric intake. Providing the diet is well balanced and contains an intrinsic component of essential nutrients, such as vitamins, minerals, etc., then an increase in caloric consumption will inevitably be linked with an increase in these nutrients. There may be some selective requirements as well.

Morgan (1961) recommends supplementing iron in pregnant women. Hytten and Duncan (1956) take the opposite view. Yet there is general agreement that the added demands of pregnancy may offset the iron balance in a marginally deficient female. Lintzel and Radeff (1931) conclude that despite large increases in iron requirements during pregnancy, there is no evidence that a practical problem exists in farm animals, because the iron needs for the fetus are supplied by maternal stores. The same can probably be said of dolphins, and for other minerals

including calcium; a female in good condition at the time of conception can be assured of continued high intake from the mineral-rich fish diet (Table 1).

Studies on the effects of deficiency of single vitamins are scarce. Severe restriction of vitamin A causes major reproductive disturbances in farm animals, especially during the latter half of gestation. Yet the vitamin requirement *per se* is thought not to be raised significantly during pregnancy. A dolphin's need is practically assured by the high vitamin A concentrations in good quality whole fish. So too are the oil-soluble vitamins D, and E. Vitamin E deficiency has been linked with reproductive failure in rats, but not in any domestic animal with the possible exception of the pig. The vitamin deserves some attention in dolphins.

The need for B vitamins in humans and most animals can be met if an increase in vitamins is proportional to the increased energy value of the diet. In other words more food needs more B vitamins, and in the case of good quality fish, more food provides more vitamins. Folic acid poses a particular problem in man. Perhaps through inadequate intake or increased excretion there is an increase in the incidence of folacin deficiency in pregnant women. The condition however, has not been observed in domestic animals.

Some consideration should be given to special food requirements, if any, during lactation. If the female has had a healthy pregnancy and has given birth to a healthy neonate, there is little likelihood of serious inadequacies in milk. Fat is an important dietary constituent in lactating animals, and higher-fat diets have generally shown a growth advantage in many domestic species (Leroy and Bonnet, 1947; Lodge, 1959; Garder and Hogue, 1963).

It may be assumed that a lactating female who is marginally deficient in vitamins will bias the health of her offspring by sparing the vitamins for her own use. This is probably true in most cases, and yet thiamine can cross the placental barrier against a concentration gradient, allowing for normal stores in fetal and nursing infants from thiamine deficient mothers (Slobody *et al.*, 1949). Certainly, future research must include a comparative survey of dolphin milk.

ARE DOLPHINS UNIQUE?

Captive dolphins present unique problems, which, for the most part are due to the very limitations of the environment. For example, their diet is restricted to 4 or 5 commercially available frozen fish species. This is a departure from their natural diet which contains a great variety of fresh fish and a small but perhaps very important component of invertebrates, including crustaceans (Gunter, 1942). Another odontocete, the beluga, consumes a curious assortment including molluscs and annelid worms, in addition to a wide variety of fishes (Vladykov, 1946). The qualitative differences between these diets are rather marked, and include differences in amino acid composition, mineral distribution, and the higher vitamin content of live foods.

These differences are obvious, and yet they need to be pointed out in order to accentuate the consequences of food deprivation which is a feature of many training programs. It has been estimated that the additional energy cost of producing a full-term human fetus is in the order of 50,000 kcal. A conservative estimate for the dolphin, which is larger and has a longer gestation period, might be 150,000 to 200,000 kcal. Assuming an 80% overall food conversion efficiency, the figure may well approach 1/4 million kcal. In terms of a lean smelt diet, this represents an added food requirement of approximately 310 kg over the course of pregnancy, or roughly an average of 1 kg/day. This assumes an immediate need for additional food at the time of conception, which is unlikely. More realistically the female's requirements are greater as pregnancy advances, so that during the third trimester, the 1 kg/day figure may well be doubled, indicating that her energy requirement may increase by 15-20%. This increased need if combined with restriction of food to below basal requirement level, which is often the case, may well place a pregnant dolphin in a 30-40% energy deficit during the period of restriction. The same order of experimental restriction of maternal diets at particular stages throughout the reproductive cycle has shown to have long range effects on the fetus and neonate. Chow and Sherwin (1965) imposed on previously well-fed rats a 50% dietary restriction during mating, gestation, and lactation. The result was a

lower birth and growth weight of the offspring, and despite *ad libitum* feeding of the pups after weaning, their body weights did not catch up to those of the control animals. Similar studies on the other species yield comparable results. The offspring are abnormally small at term, and are metabolically handicapped (Widdowson, 1968). Particular attention should be given to this problem of food restriction. Dolphin pregnancy is difficult to detect even by trained observers. What may be "standard" restrictive practice in a training program, however unnatural, will pose an even greater threat to the health of an undetected gravid female and her offspring.

Other influences on nutritional quality which set the dolphin aside from other species, are related to methods of storage and preparation of the food fish. Fish is labile and deteriorates rapidly. Dark fleshed and oily fish such as mackerel and herring have a shorter shelf life than the leaner smelt and squid. The Draft Code of Practice of Frozen Fish, (Anonymous, 1969) includes in its recommendation: to reduce the average equilization temperature to -18°C or less; and to keep the product at -18°C or less. Even at -10°C , freezing is not complete, and only 80% or so of the moisture present has been frozen. Inadequate freezer temperature and packaging result in loss of quality characterized by: cell rupture, loss of fluid and eventual dehydration; protein and water soluble vitamin breakdown and loss in the "drip"; decarboxylation of amino acids to potentially dangerous amines; fat degradation, rancidity and inactivation of fat-soluble vitamins; and loss of flavor and palatability. Even under good conditions, fatty fish should not be stored longer than 5-7 months, and mackerel under 4 months.

The method of food preparation has an effect on nutritional quality as well. Air thawing, if prolonged, can result in a 10-15% moisture loss, again, through dehydration and drip.

The storing of cut thawed fish in containers prior to feeding can also decrease moisture by 10-20%. Moisture loss alone is important to an animal which depends on food as its only water source. Moreover, the water loss carries with it water soluble vitamins and minerals, all of which may be especially important to the changing metabolic demands of pregnancy.

RECOMMENDATIONS

1. Food-deprivation is a deterrent to good health; it should not be practiced on growing females in a breeding colony, and it must be avoided with pregnant females. Heavy show schedules in which the dietary intake depends on work performed should be considered carefully during pregnancy. Depending on size, activity, and water temperature, a pregnant female *Tursiops* may require 100-200 kcal of food per kg of body weight per day.
2. Assure a good quality mixed food diet, which contains high-fat and low-fat fishes and invertebrates such as squid if possible. Higher quality can be maintained if the products are:
 - a) quick frozen and glazed, individually (I.Q.F.) or in blocks less than 6 cm thick.
 - b) packed so as to prevent evaporative moisture loss.
 - c) kept frozen at -18°C or lower.
 - d) stored for 5-7 months, and less if the above conditions are not met.
 - e) thawed as close to feeding time as possible.
 - f) fed whole or freshly cut (within the hour), not eviscerated.
3. An unrestricted high quality diet probably provides all of the necessary vitamin and mineral requirements (Table 1), including those of pregnancy. Thiamine is an exception if herring, smelt, and other thiaminase-fish are fed (Geraci, 1974). For a margin of safety, B vitamins can be supplemented.
4. Because so little is known of its consequences, and because it is unnecessary, megavitamin and megamineral therapy should be avoided.¹

¹Dolphins are sometimes subjected to whimsical and injudicious "megatherapy" programs, which include vitamins, mineral oil, ulcer preparations, drugs, etc. All are potentially dangerous. Salicylates, chloramphenicol, novobiocin, nitrofurans, and tetracyclines can adversely affect reproduction (Apgar, 1964) and should be used cautiously.

FOOD FOR THOUGHT

An interdisciplinary research effort must be undertaken in order to increase our understanding of cetacean reproduction. Both field and laboratory studies are needed in order to form a basis for comparison between wild and captive animals. In terms of nutrition, the studies should focus on the following:

- 1) Compile statistics on fetal growth and birth-weight of wild *Tursiops*, from stranded animals and from the literature. These should be compared with values of captive abortuses and stillbirths.
- 2) Using stranded and captive specimens, perform chemical analyses on milk and on fetuses and stillbirths. Data should include proximate composition, total energy values, vitamins and minerals. This will provide useful information on the nutrient costs of a fetus.
- 3) Monitor pregnant females for plasma levels of nutrients in order to help determine levels in blood needed to promote good fetal growth.
- 4) Obtain basic data on the normal physiologic adjustments that occur in pregnancy. These are needed to facilitate recognition of deviations from normal, and to help determine the added requirement, if any, of selected nutrients.

ACKNOWLEDGEMENTS

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TABLE 1: RECOMMENDED NUTRIENT ALLOWANCE FOR NONPREGNANT AND PREGNANT HUMANS AND SWINE, COMPARED WITH THE AMOUNT AVAILABLE IN THE DIET OF A *T. TRUNCATUS* (1)

RECOMMENDED DAILY ALLOWANCE

	HUMAN (18-22 YRS)		SWINE			AVAILABLE DAILY TO A 160 kg DOLPHIN (2,3)
	NONPREGNANT	PREGNANT	YOUNG (110-180kg)	PREGNANT (160-250kg)	LACTATING (200-250kg)	
Calories (kcal)	2000	2200	8250	6600	18000	16000
Vitamin A (mg)	1.5	1.8	3	2.5	5.4	60
Vitamin D (g)	10	10	17	14	30	1500
Vitamin E (mg)	25	31	-	-	-	220
Ascorbate (mg)	55	65	-	-	-	200
Folacin (mg)	0.4	0.6-0.8	-	-	-	8
Niacin (mg)	13	15	55	44	96	300
Riboflavin (mg)	1.5	1.8	10	8	19	12
Thiamin (mg)	1	1.1	-	-	-	1
Pantothenate (mg)	-	-	41	33	72	50
Vitamin B ₁₂ (g)	5	8	35	28	61	80
Calcium (gm)	0.8	1.2	19	15	41	16
Iodine (g)	115	125	500	400	400	9000
Iron (mg)	18	30-60	-	-	-	240

(1) Human data: Maternal Nutrition and the Course of Pregnancy. National Academy of Science, Washington D.C. 1970.

(2) Swine data: National Academy of Science, N.R.C. Nutrient Requirements of Swine, Ed. 7. 1973.

(3) Nutrient values calculated from data by Stansby (1962), Geraci, original data, and Englehardt *et al.*, (1975).

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GROWTH AND PHYSICAL INDICES OF MATURITY
IN THE COMMON DOLPHIN, *DELPHINUS DELPHIS*

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Mammalian growth patterns are difficult to describe accurately. Theories dealing with non-mammalian growth have been presented and supported by empirical testing (Bertalanffy, 1938; Laird, 1969). Mammalian growth, however, is more complex than growth in most other life forms. It is influenced not only by genetic factors but also external variables such as diet, activity, physical environment, and social-psychological environment. Birth, ablactation, and sexual maturity are connected with important changes in total metabolism which must affect the growth curve (Bertalanffy, 1938).

Laboratory white mice and human beings are probably the two mammalian species most closely studied for growth characteristics. These two species show similarities in their development. Any growth study of other mammals can not ignore the information obtained from human and mouse studies which are based on very large samples. Studies of the white mouse show that growth occurs in two cycles during the animal's lifetime. At the time when the first cycle ends and the second starts, not only does weaning take place but the development of sexual glands begins along with sexual differences in weight (Saller, 1932). Human growth patterns also have two periods of rapid growth (Sinclair, 1973), the second one being closely associated with sexual development (Greulich and Pyle, 1959). Although mathematical models have not been presented from these studies, the general pattern of mammalian growth can be estimated from them (Figure 1).

The general mammalian growth pattern can be considered to consist of two intersecting curves, each of which is asymptotic. The rate of growth

of laboratory mice is described by Saller (1932) as declining from birth, undergoing an explosive increase at about the time of the onset of sexual development, after which it continues to decrease. For a particular individual, the pattern is not as smooth as the curves depicted in Figure 1.

DELPHINID GROWTH

There are two approaches by which growth patterns can be studied. One method is to use a small group of newborn individuals and measure them as they grow. The other method is to acquire a very large sample such that each age class is represented. Cetacean growth studies have used the latter approach. However, acquisition of an adequate sample has always been a problem.

Most studies have concentrated on the growth patterns of the species as a whole. Individual rates and patterns unfortunately become muted when values are averaged (Sinclair, 1973). If a large change in growth or development takes place over a short period of time and the beginning of this large change does not occur at exactly the same age in each individual, the data acquired from a group of individuals will imply that the change takes place at a slower rate and over a greater period of time than is actually the case for an individual.

A study of the pilot whale, *Globicephala melaena*, (Sergeant, 1962) presents a growth curve composed from the mean values of body lengths in each age class. Age classes older than a few months had variations in growth large enough that the individuals could not be separated into age classes according to their body lengths. If presented with a single live animal, it would be extremely difficult to reliably know at what stage of growth it is, and if it is progressing normally. The same problem arises from the available information on *Delphinapterus leucas* (Sergeant, 1973). Although *Tursiops truncatus* is probably the delphinid most widely used in oceanaria and research, the data available (Sergeant et al., 1973) are too sparse to define the growth relationships between age groups.

A mathematical definition of growth in relation to age has been attempted for *Stenella caeruleoalba* (Kasuya, 1972). No single equation was found to fit the data. Three equations were used to describe three

different groups of age classes of females, with a final line, a compromise of all the mathematical descriptions, drawn by eye. The relationships for males were also drawn by eye. The growth pattern for length of *S. caeruleoalba* apparently is more complex than can be expressed by a single equation.

The recent study by Perrin *et al.* (1975) on the growth of *Stenella attenuata* presents equations which closely approximate the data. The pattern is one of intersecting asymptotic curves as in Figure 1. One equation describes the growth in the first 6 dentine layers of age. Another spurt in growth requires the employment of a second equation to approximate the remaining data. The mathematical descriptions fit the female data better than the male data. This may be partially due to using the assumption that both sexes start the second spurt of growth at the same time. Human females experience this acceleration before males (Sinclair, 1973). The two cycles of growth in *S. attenuata* intercept at about the point when the sex glands can be expected to begin development, just as in white mice (Saller, 1932) and humans (Sinclair, 1973).

THE PROBLEM

Live delphinids are expensive to obtain and their maintenance in captivity requires a significant expenditure of money and a specialized knowledge of animal husbandry. If breeding colonies are to be established, selection procedures must be applied for obtaining its members. The criteria must include at least health and sexual viability in physiological terms, if not also in social/behavioral terms.

Sexual maturity is closely linked to growth and other aspects of physical development. By monitoring a few variables of development, the proximity to sexual maturity of an individual animal can be estimated. The decision to accept or reject an individual for a breeding colony can then be made in accordance with an evaluation of the animal's sexual maturity.

MATERIALS AND METHODS

The animals used in this study were collected during various months of the year, throughout a span of several years. Specimens were acquired

during January, March, April, June, July, September, October, November and December. All were collected in the waters off the coast of southern California. Some were casualties during testing (not entirely successful) of new tuna purse seines by the National Marine Fisheries Service. In all occasions in which the specimens were acquired from seine tests, the entire herd was wrapped by the net. At least 90% of the animals escaped in each case. Those that became entangled and died in the nets were saved for scientific study. Some animals were collected individually with a hoop net from the bow of a boat with the intent of tagging and releasing them in order to study their movement patterns. A fraction of these hoop-net-collected individuals died from what is termed "capture shock". These individuals were saved for further study. A few in the study sample were animals which were found on a beach.

The analyses concentrated on examining some relatively easily measured features of delphinid anatomy. A total of 35 male and 52 female *Delphinus delphis* collected in southern California waters were used. The body weight in kilograms, and the body length in centimeters were recorded, the teeth were examined for relative age, and the bone development in the flippers was scored. Testes weights were taken and the ovaries were examined for scars.

Body Length

The body length of each animal was measured from the tip of the snout to the anterior portion of the fluke notch. The recommended standard procedure of taking the measurements in a straight line, not contour, (Norris, 1961) was followed. Data recorded to the nearest centimeter were used for analysis.

Tooth Dentine Examination

Dentine layers have been used as indicators of relative age in studies of *Tursiops truncatus* (Sergeant, 1959; Sergeant et al., 1973), *Physeter catodon* (Ohsumi et al., 1962), *Globicephala melaena* (Sergeant, 1962), *Stenella caeruleoalba* (Kasuya, 1972), *Delphinapterus leucas* (Sergeant, 1973), *Stenella attenuata* (Perrin, 1975), and *Stenella longirostris* (Perrin et al., 1975). Sergeant (1959) and Sergeant et al., (1973)

have established that one dense and one less dense layer of calcium are deposited in the dentine each year in *Tursiops*. The Black Sea population of *Delphinus* is reported to have semiannual accumulation for each pair of dentine layers (Kleinenberg and Klevezal, 1962). In the present study of eastern Pacific *Delphinus*, no attempt was made to determine the interval for dentine laminar deposition. However, it is assumed that the deposits are made at regular intervals. One light band plus one dark band are considered to compose one dentine layer.

Teeth were extracted from the posterior 1/3 of the left mandible in most cases; otherwise the largest teeth available were used for examination. A longitudinal section 15 mils (368 μ) thick was cut from the center of each tooth using a mineral saw with a diamond-dust-impregnated blade. After the samples were washed in a weak solution of ammonia to remove the oil coolant of the saw and then rinsed with water, the sections were immersed in 1-2% formic acid for etching. The etching proceeded at room temperature until the dentine growth layers were distinct, a period ranging 6-12 hours.

The sections were mounted on microscope slides with a weak solution of alcohol as the medium. Examination was conducted with transmitted light, using a compound microscope set at 37X (Figure 2).

Physical Maturity

Skeletal growth can be measured externally with simple linear measurements. However, this method provides no estimate of the final size of the individual nor how far towards that final size the individual has progressed. Physical maturity can be considered to occur when the epiphyses of the long bones fuse to the diaphysis. Skeletal growth after this event is too small to measure accurately in humans (Sinclair, 1973) and *Stenella* (Perrin, 1972). Using radiographs to measure skeletal age has been highly refined for humans (Greulich and Pyle, 1959). Skeletal development has also been studied to estimate age in dogs (Soudi, 1948; Hare, 1959; Smith, 1960; Sumner-Smith, 1966). Initial studies have been conducted on the harp seal (Sumner-Smith et al., 1972).

The different bones fuse at different times in *Stenella* (Perrin, 1972). For the present study the epiphyseal development of the flipper

bones was used as the indicator for physical maturity of the specimens. Neither chronological age nor overall body size needs to be considered when using this method.

Radiographs were taken of the flippers of each animal. These radiographs were then used in assessing the degree of development the animal had undergone. Each flipper was assigned an index by scoring the degree of epiphyseal fusion: no points were scored if the epiphysis had not been formed, one point if the epiphysis had been formed but fusion to the diaphysis had not started, two points if the epiphysis and diaphysis were in the process of fusing together, and three points were scored if the physes had been completely fused. Scores were obtained from the distal ends of the radius, ulna, metacarpals, and phalanges of each flipper. The sum of the individual epiphyseal fusion scores constituted the index for that flipper; the sum of both flippers composed the Flipper Index (FI) for that animal. In some cases, one of the flippers was damaged. The score for the undamaged flipper was doubled to obtain the FI for that animal.

The scores of the left and right flippers from 27 males were compared using the t-test for paired comparisons (Sokal and Rohlf, 1969). There is no significant differences in bone development of the left and right flippers of males with $P \leq .05$ level of confidence. The t-test for paired comparisons was also applied to 55 pairs of female flippers. There is no significant difference in bone development of the left and right flippers of females with $P \leq .05$ level of confidence. Three degrees of epiphyseal development and fusion are shown in Figure 3.

Testes Development

Each testis, with the epididymus removed, was weighed and the weight recorded in grams. No histological information nor morphometrics from the testes were collected for this study. The combined testes weight for each animal was used as a measure of sexual maturity. The weights of the left and right testes were compared on 34 animals, using the t-test for paired comparisons (Sokal and Rohlf, 1969). There was no significant difference in weight between the left and right testes at $P \leq .05$ level of confidence.

In this study, the minimum weight for a pair of testes to be considered sexually mature is 350 gm, the size at which the testes begin their rapid growth.

Ovarian Development

The scars occurring on delphinid ovaries do not have a meaning which is agreed upon by all cetologists. In the present study, an ovarian scar was interpreted to indicate activity related to, if not actually represent, ovulation. Just as menarche in human females does not mean ovulation but the final developmental stages for the ability to ovulate, the formation of delphinid ovarian scars is inferred to indicate ovulatory capacity.

The ovaries were not scored according to their degree of development. They were just noted as mature or immature. Maturity was indicated by the presence of at least one corpus albicans or a corpus luteum. However, each ovary also was sliced into sections 1 mm thick and examined for corpora, and the total number of these structures was recorded for each ovary. In all but 2 of 25 mature cases, the left ovary had more scars.

RESULTS

Epiphyseal Fusion Pattern

The sequence of epiphyseal fusion in the flippers of *D. delphis* appears to follow a distinct pattern. The epiphyses first develop in the distal ends of the radius and ulna, followed by the metacarpals, then the more proximal end of each bone, then on the distal end. The proximal ends of the radius and ulna were not noted. The digits also show a specific sequence of growth. Bone development starts in the second digit, followed by the third, fourth, first and fifth.

The epiphyses of the more distal phalanges are not individually noticeable. The shapes of the ends of these distal phalanges seem to change from concave to convex as they develop. The most distal phalanges remain as bone nodules, spherical in shape. Increases in bone densities of the proximal and distal surfaces of these bone nodules occur at about the same time as in those of the more proximal phalanges which have developing epiphyses.

Final fusions of the physes of all the phalanges seem to occur over a narrower time range than that of epiphyseal formation. This event corresponds with the end of the period of rapid skeletal growth and the onset of sexual maturity (Greulich and Pyle, 1959). It can be inferred from Figure 5 that the FI scores 80-110 span this transitory event.

Male Data Analysis

A log transformation was performed on the testes weights to make the data more manageable. The resultant values were plotted against body length, age, and flipper bone development. The same animals were used for three analyses (Figures 4, 5 and 6), so a direct comparison of the results is not affected by differences in the samples used. Because the data are not normally distributed, the non-parametric Kendall's rank correlation coefficient (Sokal and Rohlf, 1969) was calculated for each of the three sets of data pairs. Each pair of variables was significantly correlated at $P \leq .001$ level of confidence.

There is a definite age range (7-12 layers) in which it is not possible to estimate with any reliability the size of the testes. The shaded area of Figure 4 highlights this range of poor predictability.

When the combined testes weight is plotted against the body size, the same situation occurs (Figure 5). An animal 175-190 cm long can not reliably have its gonadal development estimated. The data presented for the comparable-sized *Stenella attenuata* (Perrin et al., 1975) also show a wide spread in combined testes weights in the 175-190 cm range.

A reasonably reliable estimate of gonad development can be obtained if the degree of physical maturity, not size, of the individual animal can be measured. When the Flipper Index is used to indicate physical maturity, testes development apparently can be reasonably estimated throughout the entire range of the FI.

A least squares regression line had been calculated in order to allow prediction of the combined testes weight when the FI is known (Figure 6). This line is for immediate practical convenience only and may not be the best description of the relationship. The data were not collected nor are they distributed appropriately to meet the assumptions required to compute

a regression line with any statistical propriety. Until more data become available, the mathematical relationship presented must be considered only tentative.

Another approach using morphology to indicate sexual maturity is by measuring robustness. The Robustness Quotient (RQ) is defined as the body length in centimeters divided by body weight in kilograms. The RQ is plotted against the body length (centimeters) of the male *Delphinus* in Figure 7. It is apparent that the robustness of the animal increases (RQ decreases) with body length. Although an individual may be long, weight is also an important factor in order for sexual maturity to occur. Only the most robust individuals can be considered to be sexually mature. The data indicate that sexual maturity is not reached until the animal's RQ is less than about 2.6. The number of males considered sexually mature in this analysis was very small. Any statistical treatment to estimate RQ ranges and confidence limits for mature males would produce such tentative results that none was applied. The data used in this analysis are not exactly the same as those used in the other comparisons since weight data were not available in all cases.

Female Data Analysis

The data for the females were treated generally in the same fashion as were the data for the males. No data were submitted to log transformation, however. The number of ovarian scars was compared to the relative age, body length, and flipper bone development. Although most of the specimens are the same for each analysis, the samples are not identical.

The relative ages of the females as expressed in dentine layers were used as a base against which the total number of ovarian scars was plotted (Figure 8). Immature animals occur throughout a wide age range (7-14 dentine layers), indicating that age alone is not an adequate criterion on which to base a determination of sexual maturity. The shaded portion of the scattergram indicates the ages over which animals with active and inactive ovaries occur.

The body length of *Delphinus* females is also an inadequate indicator of ovarian scarring. The data presented in Figure 9 show there

is an overlap in body length of obviously sexually immature animals with those having several ovarian scars. The overlap occurs in approximately the 165-182 cm range. Immature females also occur in comparable age ranges and sizes in *Stenella attenuata* (Perrin et al., 1975).

Unlike the males, in females the Flipper Index is a poor measure to indicate sexual development. There exists a wide range of physical maturity in which inactive ovaries occur (Figure 10).

Although the samples for the above comparisons are not identical, the data imply that some females never ovulate. Similar data indicating this has been previously reported in the literature (Harrison et al., 1972). If that is really the case, the role, if any, of these non-ovulating animals in the *Delphinus* social structure may be very special within the realm of mammalian social organization.

In studies of humans, it was found that girls who attained early menarche also had greater weight for height than their chronological peers who attained maturity at a later time (Simmons and Greulich, 1943). The Robustness Quotient suggests a similar relationship in *Delphinus*.

Of the 24 females with ovarian scars in this study, 16 were pregnant. In order to calculate a reasonable RQ for these animals, twice the weight of the fetus was subtracted from the gross weight of the mother. Assuming the weight of the amniotic sack is nearly equal to that of the fetus, the resultant value is the weight of the unpregnant female. The mature females had an RQ lower than old large females that had never ovulated (Figure 11). The data points of those animals with unscarred ovaries are distributed along only the periphery of the area occupied by that of the mature animals. The RQ value apparently can separate the female *Delphinus* with active ovaries from those with inactive ovaries.

DISCUSSION

Onset of Male Sexual Maturity

Growth studies on humans show that individuals progress through the stages of puberty at a rapid rate, but not in synchrony with their chronological peers (Sinclair, 1973). There is a large range between the individuals in height, weight, and skeletal maturity during the time of

puberty as indicated by the development of the bones of the hand and wrist of humans (Greulich and Pyle, 1959).

The ranges over which sexual maturity occurs in *Delphinus* can be inferred from the presented data. There appears to be a virtual quantum leap in combined testes weight, from less than 80 gm to almost 400 gm. Recognizing that the sample size is small, one can nevertheless reasonably infer that this large step corresponds with a period of rapid skeletal growth in the individual dolphin, just as that pattern is demonstrated in mice (Saller, 1932) and humans (Greulich and Pyle, 1959). If testes weight is a reasonable measure for sexual maturity, 7-12 dentine layers are the relative ages over which the range of sexual maturity occurs (Figure 4). Puberty in *Stenella attenuata* is reported to occur over the same range (Perrin et al., 1975). The range of body lengths which has the greatest span of testes weight is 175-190 cm (Figure 5). Animals which exhibit more than 12 dentine layers or are longer than 190 cm have assuredly attained sexual maturity. Within the age and size ranges where puberty occurs, selection of the mature from the not yet mature can be accomplished by using the Flipper Index since it is a finer measure of skeletal and testes development.

Gaps in the data occur in the ranges just prior to the onset of *Delphinus* sexual maturity. There appears to be a hiatus in the male data in the range of FI scores 85-105 (Figure 6). This corresponds with 158-177 cm in body length (Figure 7) in which there are only two specimens, and the range of 4-8 dentine layers (Figure 8) in the males in which there is only one specimen. This gap can be interpreted to be the pre-puberty range in *Delphinus*.

Separate herding behavior could explain the absence of specimens in these age and size ranges. In other cetaceans, young males frequently herd separately from the rest of the population. This behavior has been reported for *Physeter catodon* (Ohsumi, 1971) and *Tursiops truncatus* (Evans and Bastian, 1969). The gap in the data could also indicate that these animals have a greater capacity to escape nets than the other age groups.

The data used in this study were not biased due to specimen collection relative to a season of rut. Specimens which had combined testes

weights exceeding 350 gm were collected in March, April, July, September, October, November and December. Histological studies on *Delphinus* from the eastern tropical Pacific show that the smallest testis to show spermatogenesis weighed 140 gm (Charles Oliver, unpublished data). Although no histological examinations were performed on the specimens used for the present study, seasonal rut is not indicated. Harrison et al. (1969), have also found *Delphinus* testes to be active all year round.

Evidence for seasonal calving has also been presented (Evans, 1975). If breeding in *Delphinus* is indeed seasonal, the immediate controlling factor appears to be something other than simply the physiological state of the male.

Female Sexual Maturity

Ovarian scars do not appear to occur in regular intervals within any of the variables measured for this study. At any given age there is a wide range of recorded ovarian corpora (Figure 8). The youngest mature animal had 16 scars while the oldest had only 5. The mature individuals with ages between those extremes had 1-13 corpora. A non-parametric Kendall's rank correlation test (Sokal and Rohlf, 1969), comparing the number of corpora in mature individuals against their ages (dentine layers), shows no significant relationship at $P \leq .10$. The same correlation test run to compare the mature ovary record in relation to body size (Figure 9) and also to physical maturity (Figure 10), reveals no significant relationship at $P \leq .10$. *Stenella attenuata* data (Perrin et al., 1975), also displayed a high degree of scatter when the ovarian corpora are examined in relation to age and size. Harrison and Ridgway (1971) concluded that ovulation in *Tursiops* is induced. The data presented here do not conflict with that possibility for *Delphinus*.

The data for the females appear to be relatively sparse in the regions just prior to the demonstration of ovarian scars. Since the samples for each of the comparisons were not composed entirely of the same animals, it is difficult to directly compare the several graphs. However, in Figure 9 there is only one datum in the 153-165 cm range which immediately precedes the lengths in which sexually mature females

occur. Also, there are only two data points in the range of 3-6 dentine layers (Figure 8), and the first sexually mature female occurs at seven layers. Similarly, the FI range 30-70 is occupied by only two animals and the first occurring sexually mature individual has an FI of 72 (Figure 10). The data therefore indicate either that preadolescent females, like the males, have a behavioral pattern which allows them to escape net sets with greater facility, or they have a social structure which keeps them separate from the main herd.

General

Although this short study was based on *Delphinus*, an animal rarely maintained in the U.S., the techniques presented can easily be applied to other delphinids. Epiphyseal development and fusion are events occurring throughout the class of mammals. Their use as indicators of physical maturity enables one to assay the development of individual animals with equal accuracy regardless of their taxonomic status. New sonic doppler devices may possibly be used to acquire the same flipper data as the x-ray machine, thereby offering greater equipment mobility and less operation hazard.

The Robustness Quotient appears to give good results as an indicator for sexual maturity. A greater weight for height has been shown for early maturing human females, so the relationship of robustness and sexual maturity is not unique to delphinids. Of the methods presented, it is the best indicator for use with female *Delphinus*. Calculating the RQ requires inexpensive equipment and is easy to perform.

The data necessary to perform a comparable study on *Tursiops truncatus* are not available. If length, weight, a posterior tooth (techniques for extraction are described by Ridgway *et al.* (1975)), and flipper radiographs are obtained when each animal is captured and also collected periodically throughout its life, an immense body of data can rapidly be accumulated due to the large number of *Tursiops* currently captive. Post-mortem collection of the gonads would help round out the data base. Since the bottlenosed dolphin is probably the most widely used delphinid employed both for display in oceanaria and for research, there are many opportunities for collection of data.

CONCLUSIONS

A two-cycle growth pattern occurs in *Delphinus*. A study of *Stenella attenuata* presents data which also fit the two-cycle growth pattern.

Sexual development in *Delphinus* as in *Stenella* appears to start at the beginning of the second growth cycle. Sexual maturity occurs when the individual has almost attained physical maturity. The Robustness Quotient appears to be a good indicator of female ovarian history. The degree of physical maturity indicated by the Flipper Index is a good measure of testes size.

No correlation of ovulation with age, length, or Flipper Index was found in female *Delphinus*.

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 3. Process of fusion of the epiphyses to the diaphyses. Flipper index values were obtained from the distal ends of the radius, ulna, metacarpals, and phalanges of each flipper. No points were scored if the epiphysis had not been formed; one point if the epiphysis had been formed but fusion to the diaphysis had not started; two points if the epiphysis and diaphysis were in the process of fusing together; and three points were scored if the physes had been completely fused. The sum of the individual fusion scores constitutes the index value for that flipper. The flipper labeled A has a score of 18; B, 49; and C, 72.
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 6. Development of testes and bone development of the pectoral appendages in *Delphinus*. The least squares regression line is for convenience only and is not statistically appropriate. Another shape of line may be more appropriate but the data are insufficient.

Figure 7. Robustness as related to body length in male *Delphinus*. The Robustness Quotient is computed by dividing the body length (cm) by the body weight (kg). Individuals with combined testes weights of 350 gm are considered to be undergoing spermatogenesis. The shaded area is the region in which mature males apparently occur.

8. Ovarian corpora in relation to age in *Delphinus*. The stippled region is the age range in which sexually mature animals can not be distinguished by dentine laminae.
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11. Robustness relationship to body length in female *Delphinus*. The triangles represent individuals with at least one ovarian corpus. The shaded area is the region in which sexually mature animals occur. The immature animals falling within this region are on the perimeter only.

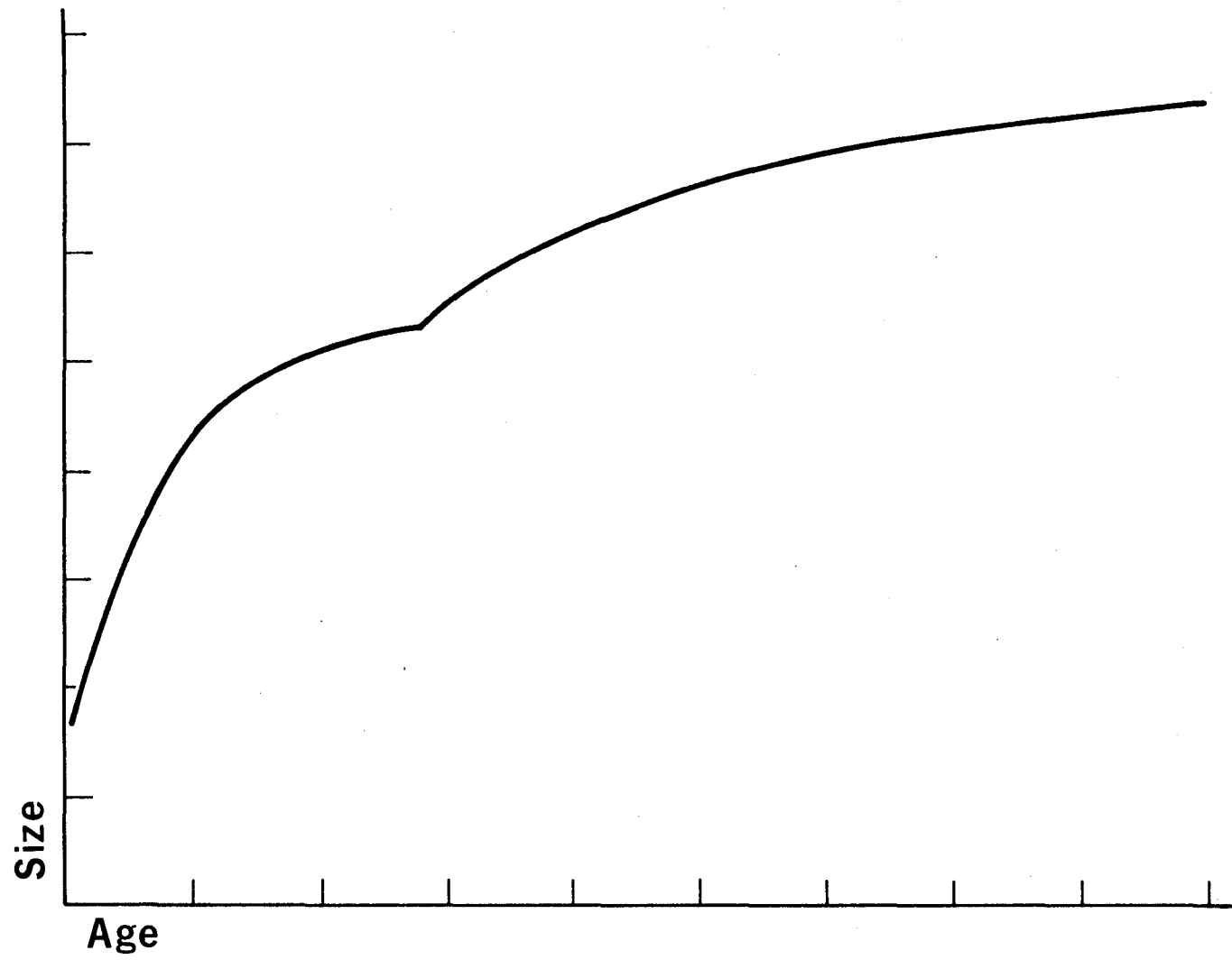
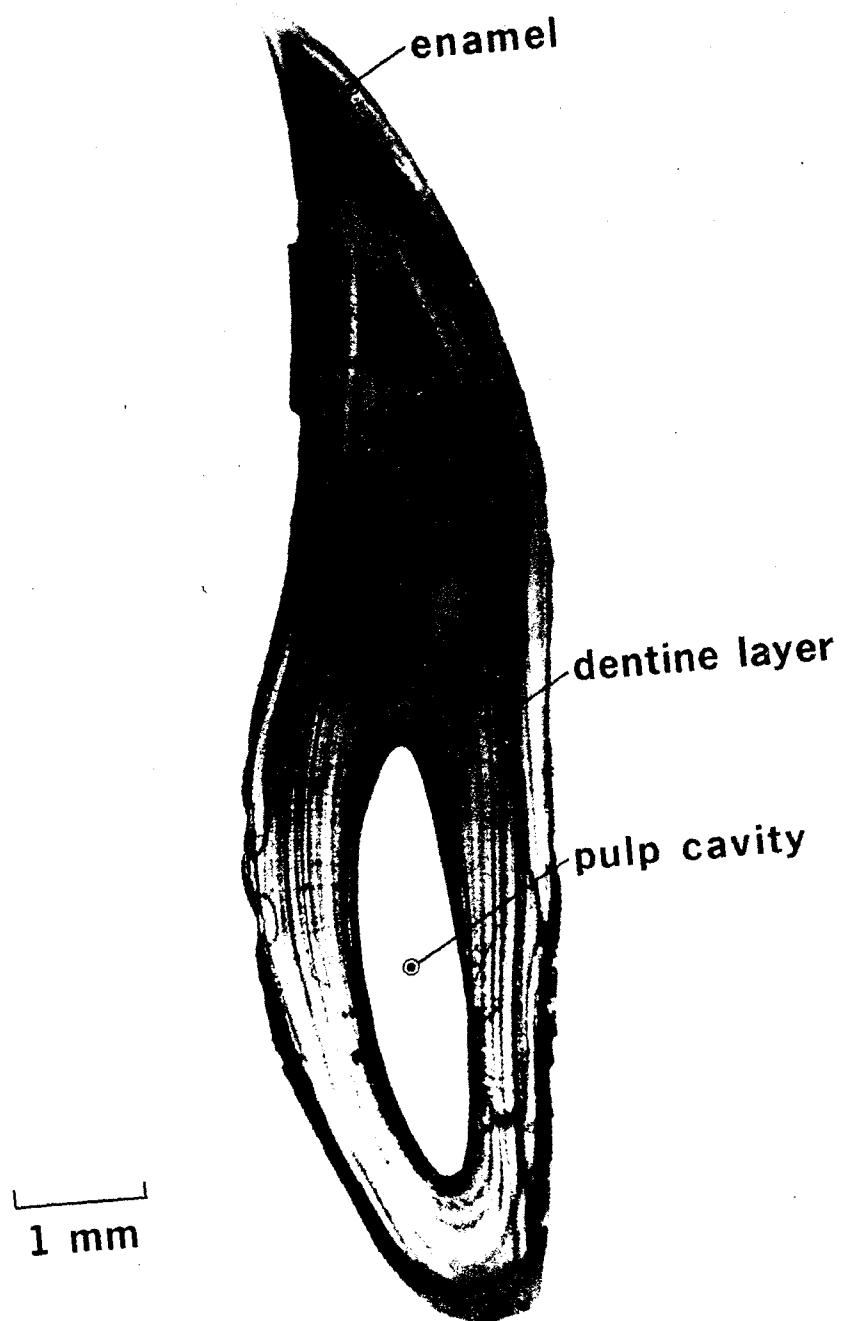


Figure 1. SUGGESTED GENERAL MAMMALIAN GROWTH CURVE



SECTION OF DELPHINUS TOOTH

Figure 2



A



B



C

Figure 3

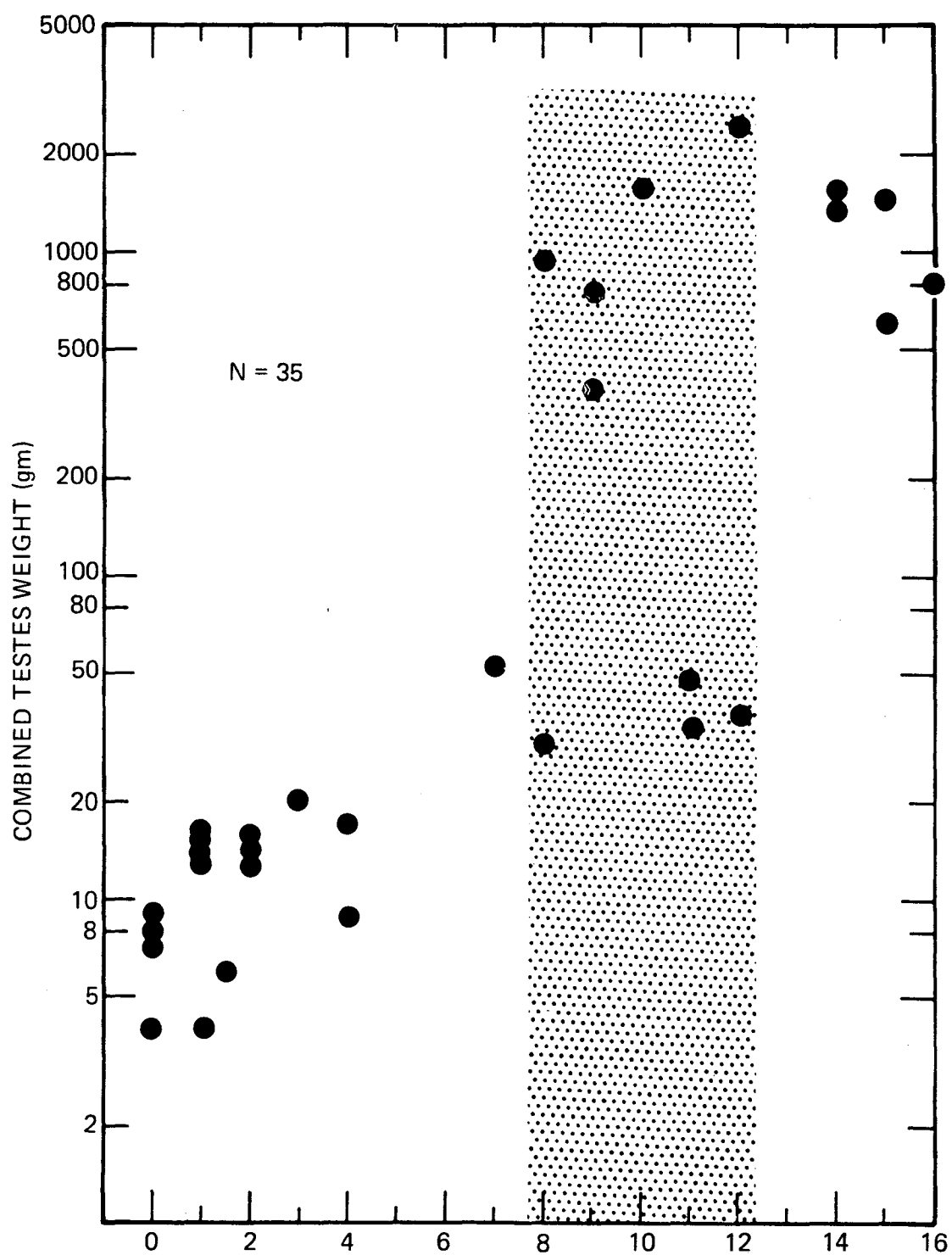


Figure 4. DENTINE LAYERS

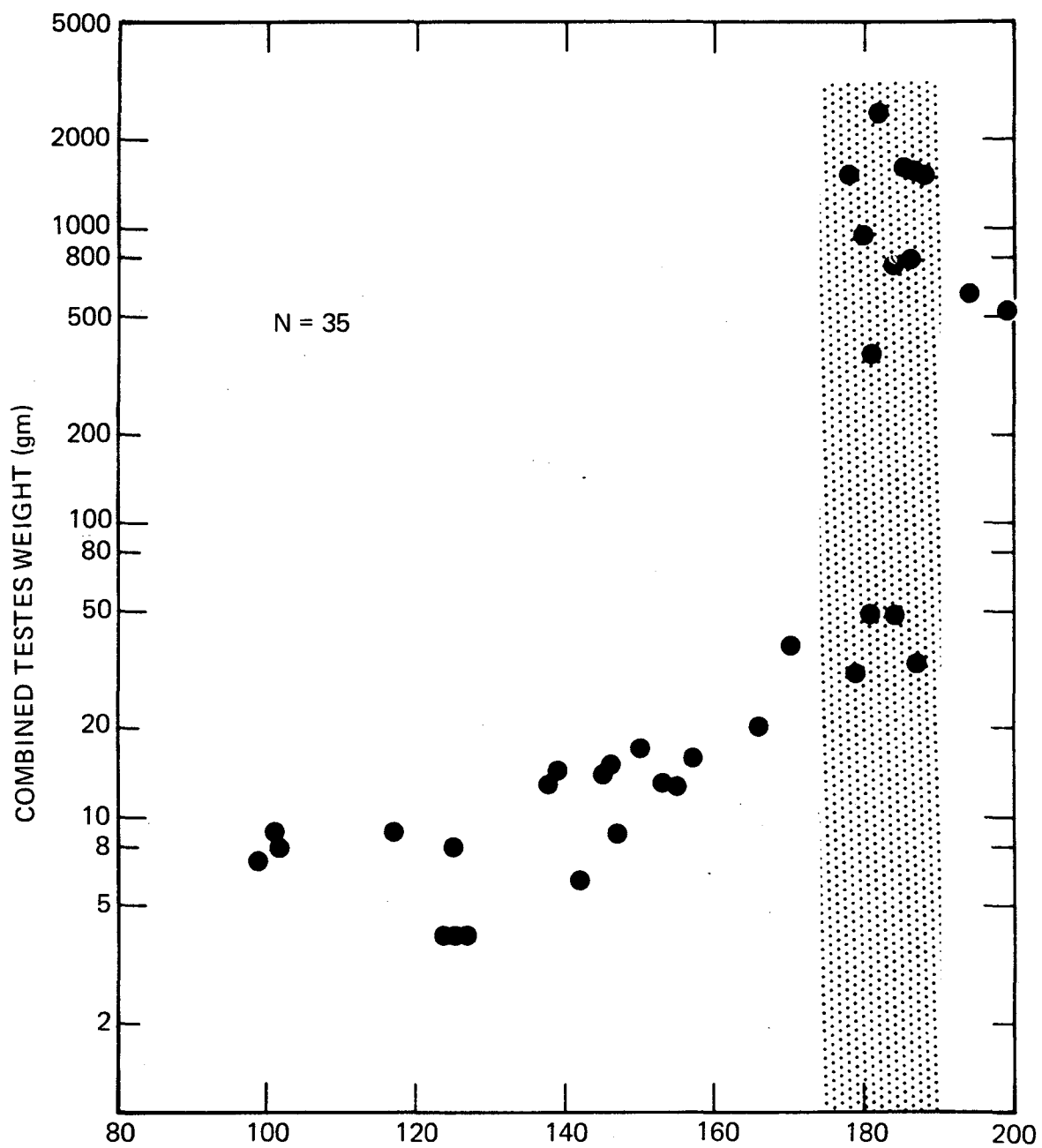


Figure 5. TOTAL BODY LENGTH (cm)

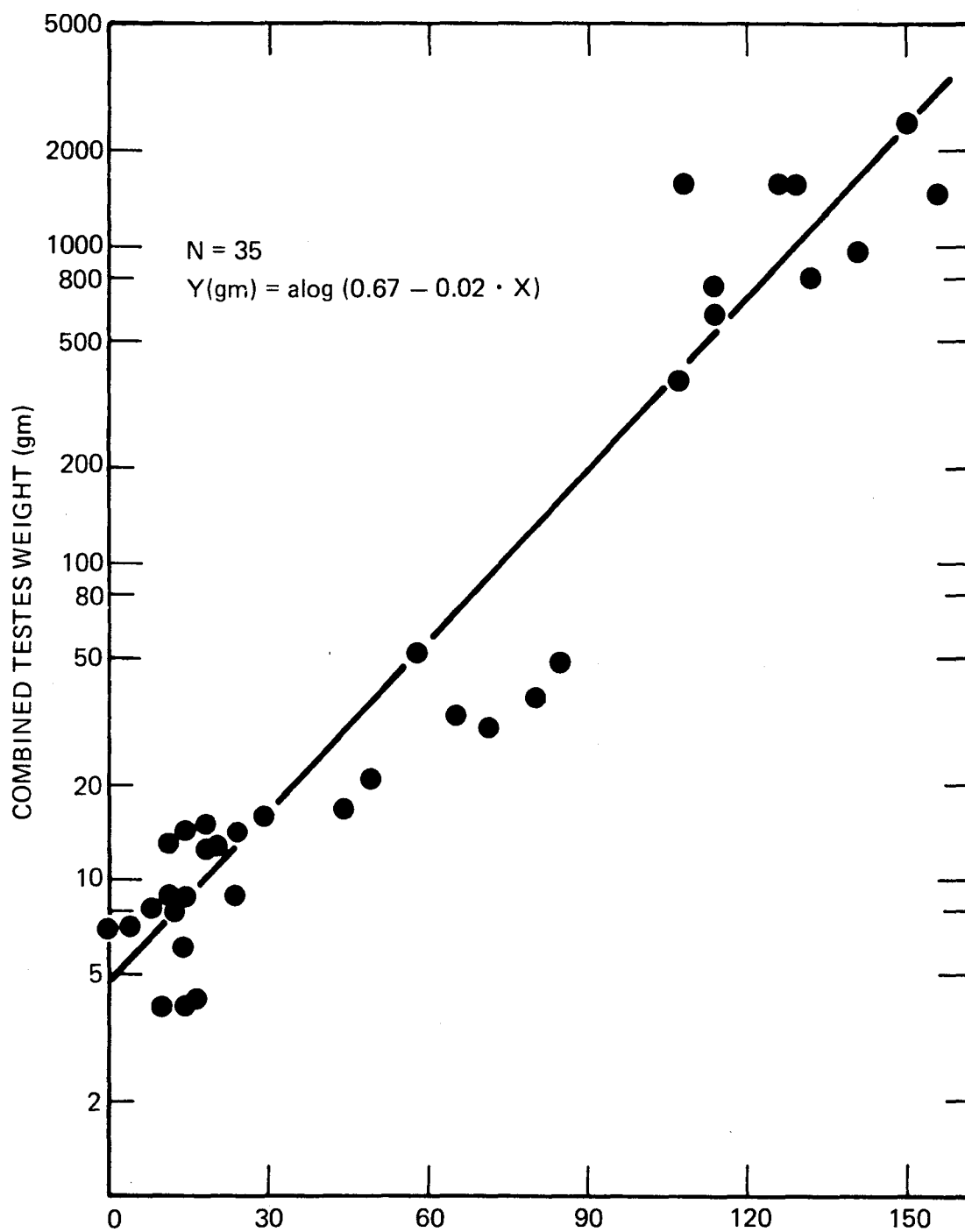


Figure 6. FLIPPER INDEX

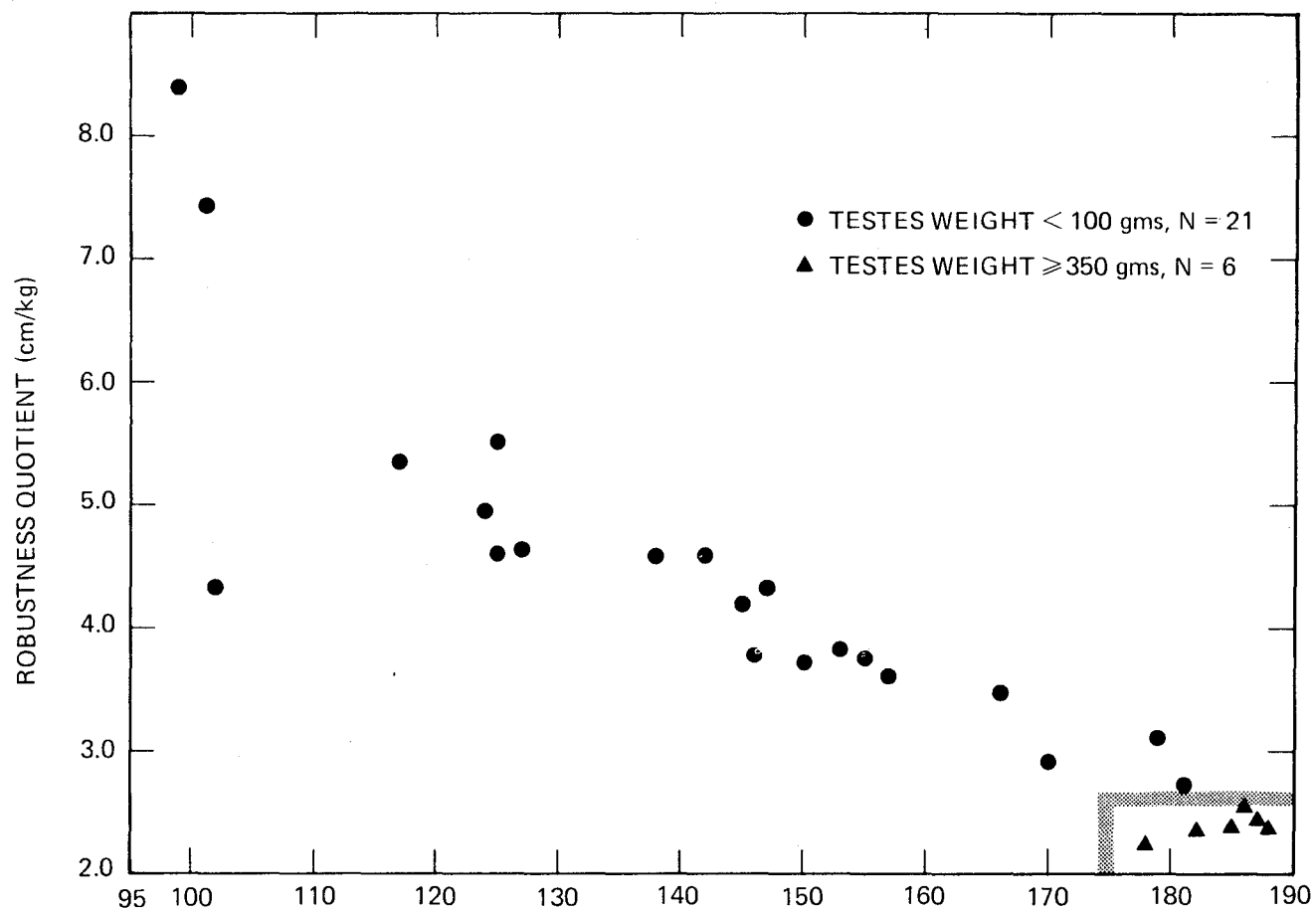


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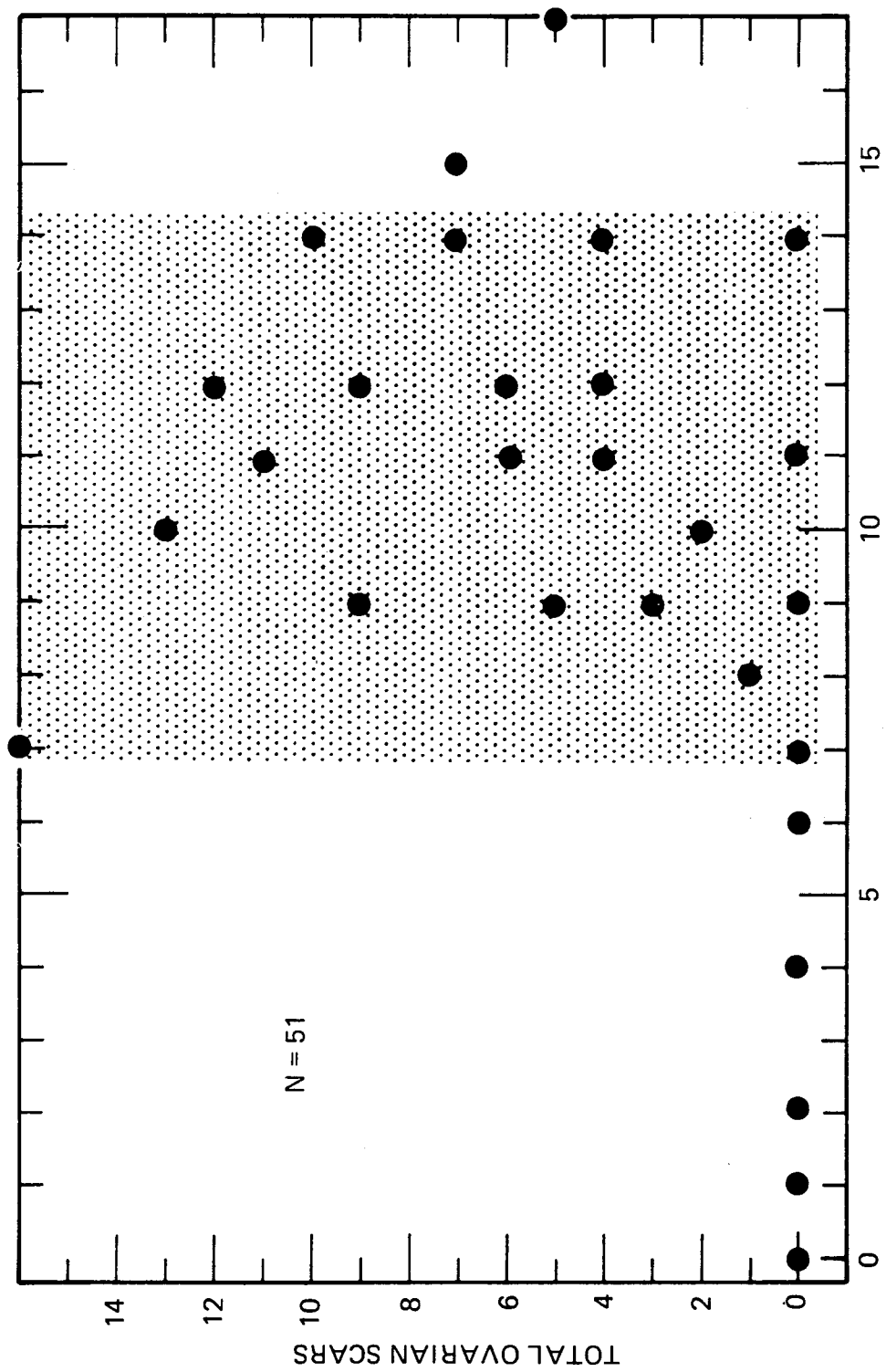


Figure 8. DENTINE LAYERS

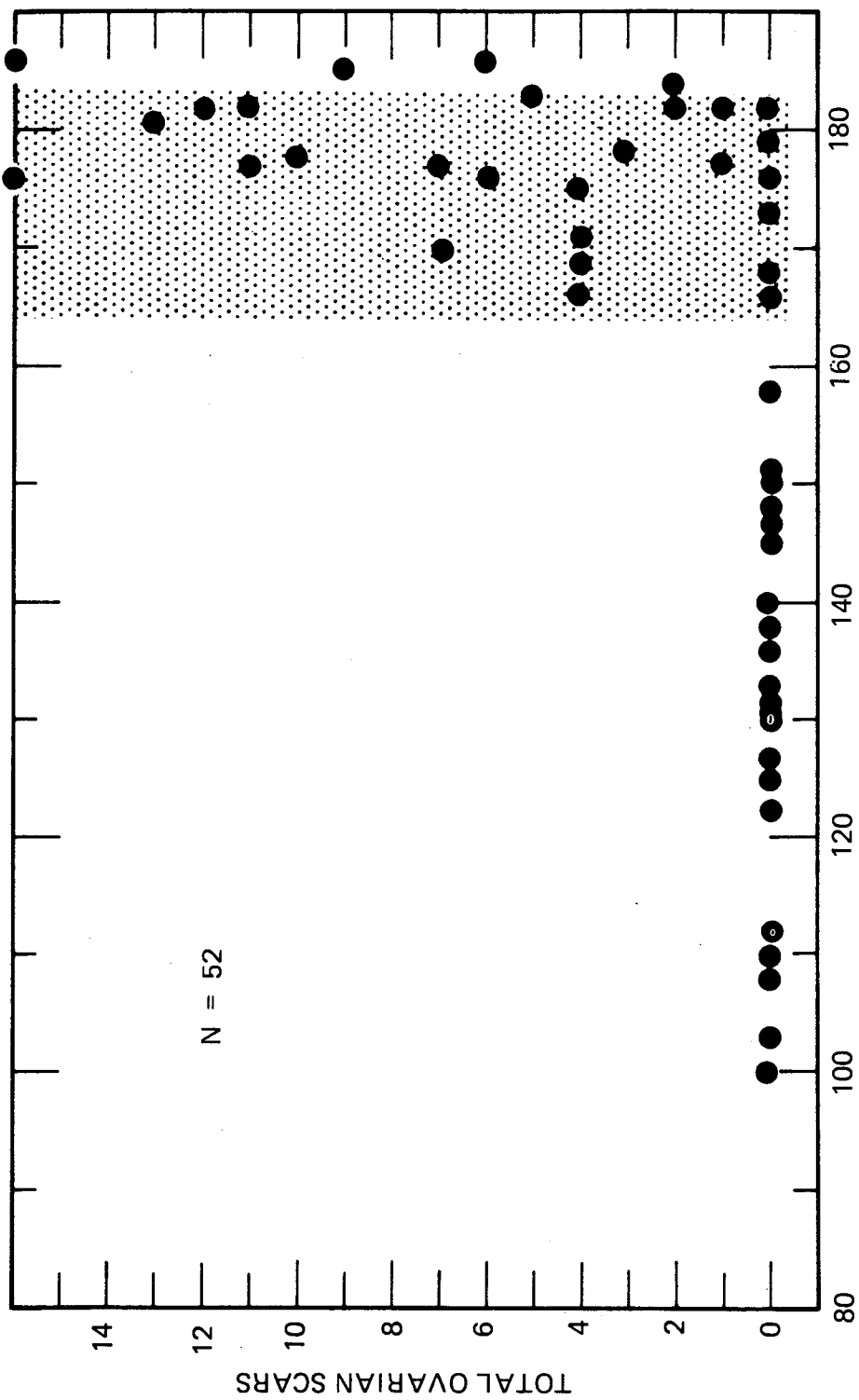


Figure 9. BODY LENGTH (cm)

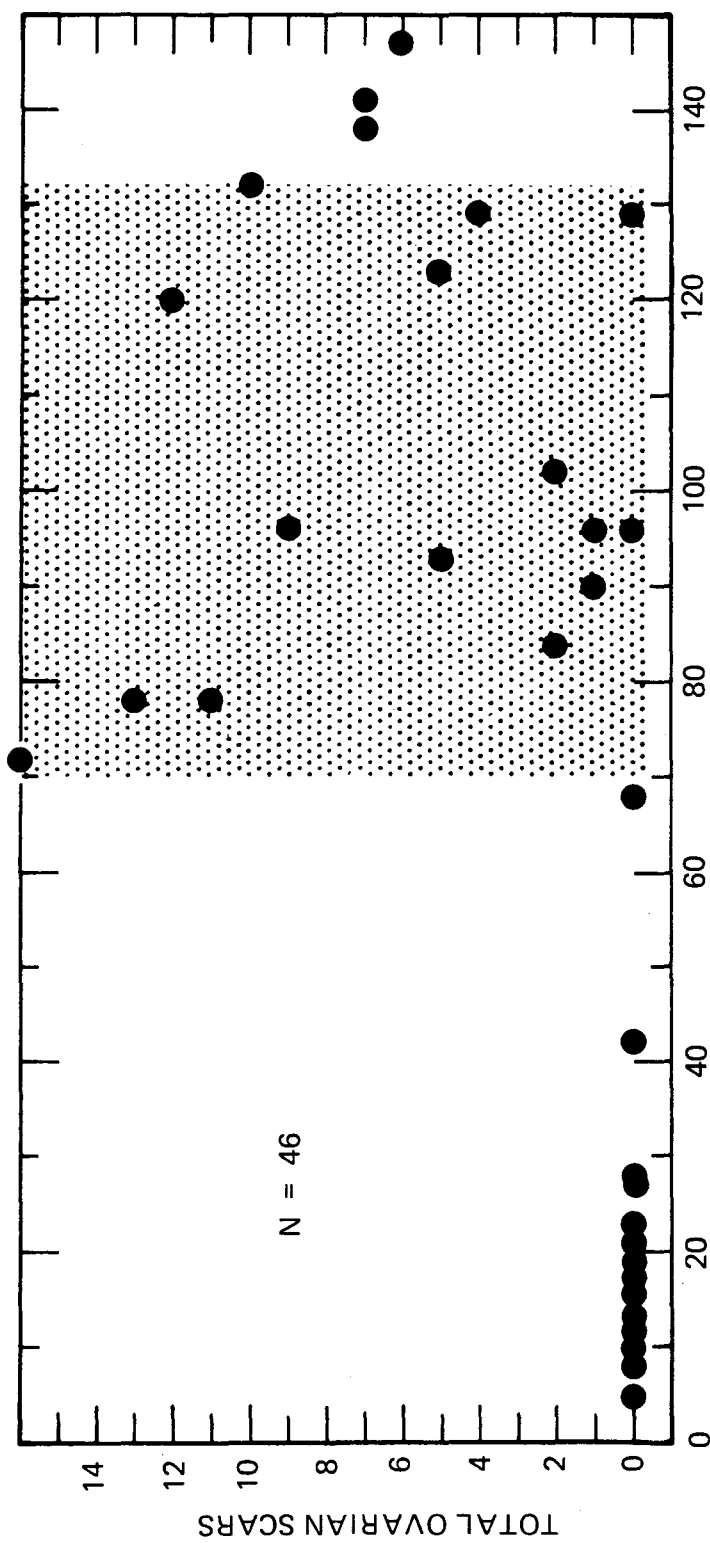


Figure 10. FLIPPER INDEX

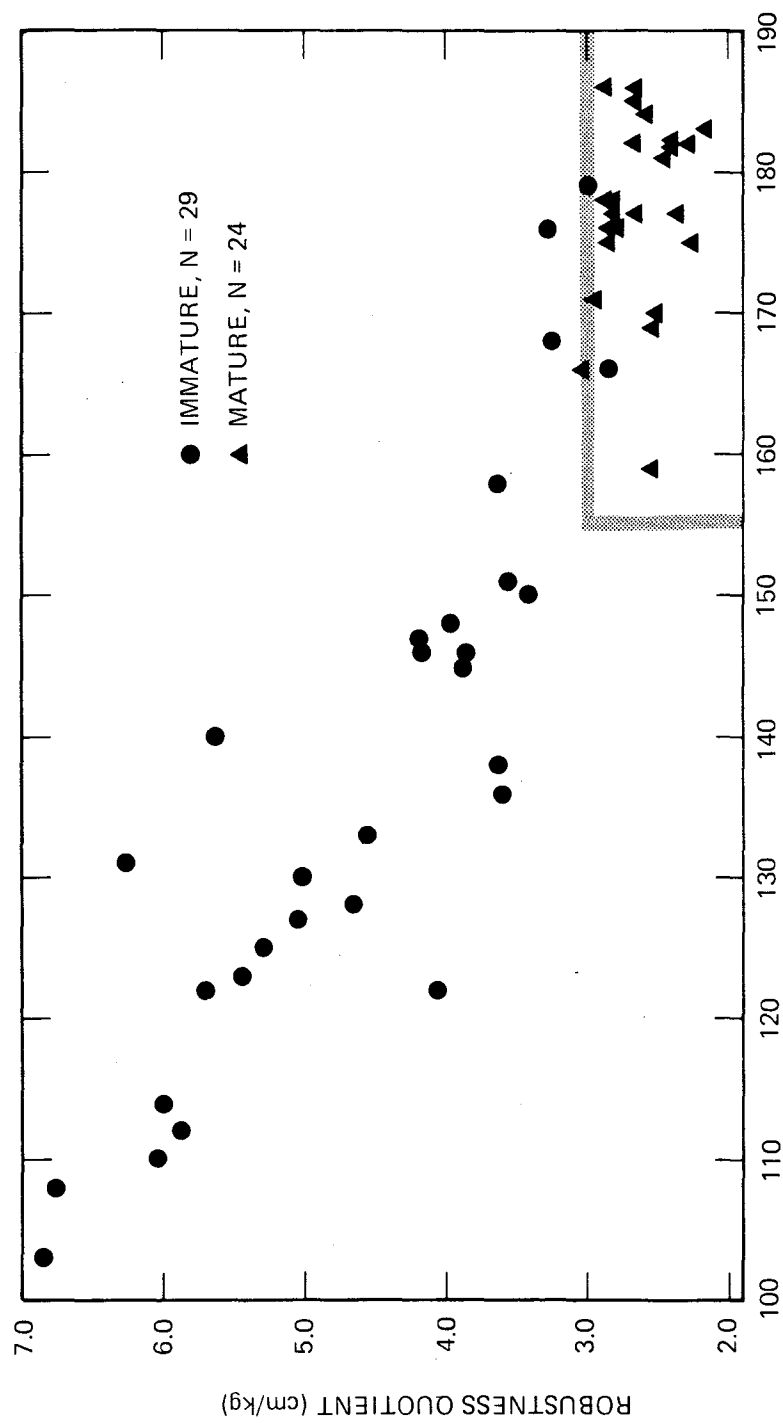


Figure 11. BODY LENGTH (cm)

STEROID HORMONE STUDIES IN PREGNANT AND NONPREGNANT
BOTTLENOSED DOLPHINS, *TURSIOPS TRUNCATUS*

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INTRODUCTION

The development of radioimmunoassay techniques has provided the means to measure hormones in small amounts of blood from animals sensitively, precisely, accurately, and specifically (Neil, 1967; Hotchkiss, 1971; Richkind, 1973).

The lack of sufficient baseline hormone values with respect to the estrous cycle of the bottlenosed dolphin, coupled with either nonspecific reproductive behavior or very subtle changes in reproductive behavior creates a problem in studying the propagation of the species in captivity. In order to gain an insight into the possible roles of the plasma pattern levels of estrogens, progestagens, and corticosteroids, the introduction of a marker is used as a point of reference.

Although the ovary and testes produce steroid hormones, the adrenal cortex also produces these hormones. The question that arises is whether the steroid hormones which are being produced are coming from the gonads or the adrenal cortex or both. Since cholesterol is the parent steroid substance, and two major pathways exist under the control of 3 beta-hydroxysteroid dehydrogenase, it becomes of interest to measure the major steroid hormones present after the introduction of a metabolic marker.

In a previous study (Richkind, 1975), the plasma levels of estrogens, progestagens, and corticosteroids in pregnant and nonpregnant bottlenosed dolphins were noted to have an inconsistent pattern. Also, the plasma levels of estrogens, progestagens, and corticosteroids in the bottlenosed dolphin were influenced more strongly by pregnancy than by the administration of follicle stimulating hormone.

Consequently it has become of interest to examine these parameters in an ovariectomized bottlenosed dolphin after the administration of follicle stimulating hormone.

METHODS

Blood samples from a captive adult ovariectomized bottlenosed dolphin, *Tursiops truncatus*, were collected as described by Ridgway (1965). Water was drained from the dolphin tank and the animal was guided onto a stretcher. The stretcher was then lifted out of the water and secured. Blood was withdrawn from the central vessels on the ventral aspect of the flukes. All blood samples were collected in heparinized syringes and centrifuged. The plasma was removed and frozen at -20°C.

Plasma levels of estrogens, progestagens, and corticosteroids were measured from blood samples taken at 0830 and 1430 for five continuous days, then at 0830 on the eighth and tenth days. Initially, the first blood sample was followed by the intravascular administration of 10 mg NIH-FSH-BOVINE-B1, followed by a one hour post injection blood sample.

The plasma levels of estrogens, progestagens, and corticosteroids were measured as described in a previous study (Richkind, 1975).

RESULTS AND DISCUSSION

Initially, plasma levels of estrogens decreased one hour after the administration of NIH-FSH-BOVINE-B1, while the plasma levels of progestagens, and corticosteroids were unchanged. However, five hours after the administration of NIH-FSH-BOVINE-B1, the plasma levels of estrogens, progestagens, and corticosteroids decreased maximally. The morning and afternoon of the first day of sampling were characterized by plasma levels of estrogens, progestagens, and corticosteroids as increasing and decreasing in tandem. The second day post injection was characterized by increasing plasma levels of estrogens, but decreasing plasma levels of progestagens and corticosteroids. The morning of the third day post injection, the plasma levels of estrogens decreased. The afternoon of the third day post injection was characterized by increasing plasma levels of estrogens, progestagens, and corticosteroids, which

reached their maximal values on the morning of the fourth day post injection. On the afternoon of the fourth day post injection, the plasma levels of estrogens, progestagens, and corticosteroids decreased in tandem. On the seventh day post injection, there was an increase in the plasma levels of estrogens, progestagens, and corticosteroids. On the ninth day post injection, the plasma levels of estrogens and corticosteroids decreased while the progestagens remained unchanged.

After the administration of 10 mg NIH-FSH-BOVINE-B1, plasma levels of estrogens in an ovariectomized bottlenosed dolphin varied from 5.0 pg/ml to 11.0 pg/ml, while the plasma levels of progestagens varied from undetectable to 0.3 ng/ml, and the plasma levels of corticosteroids varied from 9.0 ng/ml to 32 ng/ml.

As was noted in a previous study (Richkind, 1975), the plasma levels of estrogens, progestagens, and corticosteroids are characterized by having an inconsistent pattern. However, in the present study with the ovariectomized animal a less complicated pattern exists after the intravascular administration of 10 mg NIH-FSH-BOVINE-B1. The tandem decrease in the plasma levels of estrogens, progestagens, and corticosteroids five hours after the intravascular administration of NIH-FSH-BOVINE-B1, and the increase in plasma levels of estrogens with tandem decrease in plasma levels of progestagens and corticosteroids on the second day post injection tends to suggest a possible alternative pathway of steroid hormone metabolism by the adrenal cortex. The existence of two major pathways for the production of estrogen under the control of 3 beta-hydroxysteroid dehydrogenase makes an attractive hypothesis. However, further purification and identification of steroid hormone intermediates is needed.

When comparing plasma levels of estrogens and progestagens in the present study with a previous study (Richkind, 1975), one observes a difference between pregnant and nonpregnant individuals. Individuals which are pregnant six months or longer have higher plasma levels of estrogens and progestagens than do nonpregnant individuals. An individual without ovaries has lower plasma levels of estrogens and progestagens than individuals with ovaries.

CONCLUSION

Peripheral plasma levels of estrogens, progestagens, and corticosteroids in an ovariectomized bottlenosed dolphin are influenced by the intravascular administration of 10 mg NIH-FSH-BOVINE-B1. This influence is characterized by an increase in plasma levels of estrogen which may or may not be accompanied by parallel increases in plasma levels of progestagen and corticosteroid. The plasma levels of progestagens and corticosteroids tend to parallel each other. The possible source of the peripheral plasma levels of estrogens is the adrenal cortex. Furthermore, the data tend to suggest more than one metabolic biosynthetic pathway for the peripheral plasma levels of estrogens.

Peripheral plasma levels of estrogens and progestagens in the bottlenosed dolphin are lowest in the absence of the ovaries, higher in individuals with ovaries, and highest in individuals which are more than six months pregnant.

ACKNOWLEDGEMENTS

The NIH-FSH-BOVINE-B1 was a gift from the National Institutes of Health, Bethesda, Maryland.

The author wishes to thank Sam H. Ridgway of the Naval Undersea Research and Development Center, San Diego, California, for his interest and cooperation in this project.

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FIGURE 1: COMPARATIVE ESTROGEN HORMONE PATTERNS
AFTER ADMINISTRATION* OF FOLLICLE
STIMULATING HORMONE IN *TURSIOPS TRUNCATUS*

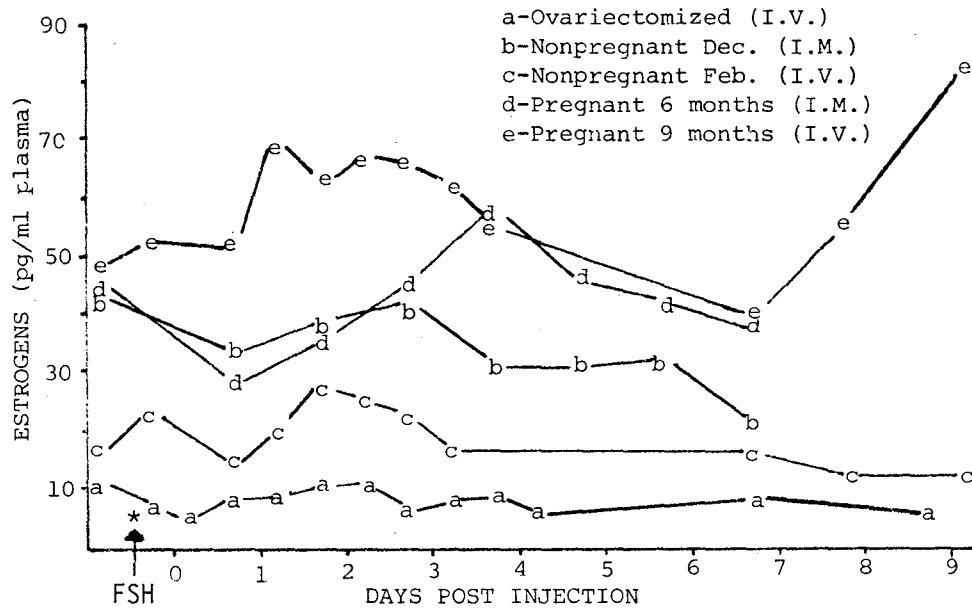


FIGURE 2: COMPARATIVE PROGESTAGEN HORMONE PATTERNS
AFTER ADMINISTRATION* OF FOLLICLE
STIMULATING HORMONE IN *TURSIOPS TRUNCATUS*

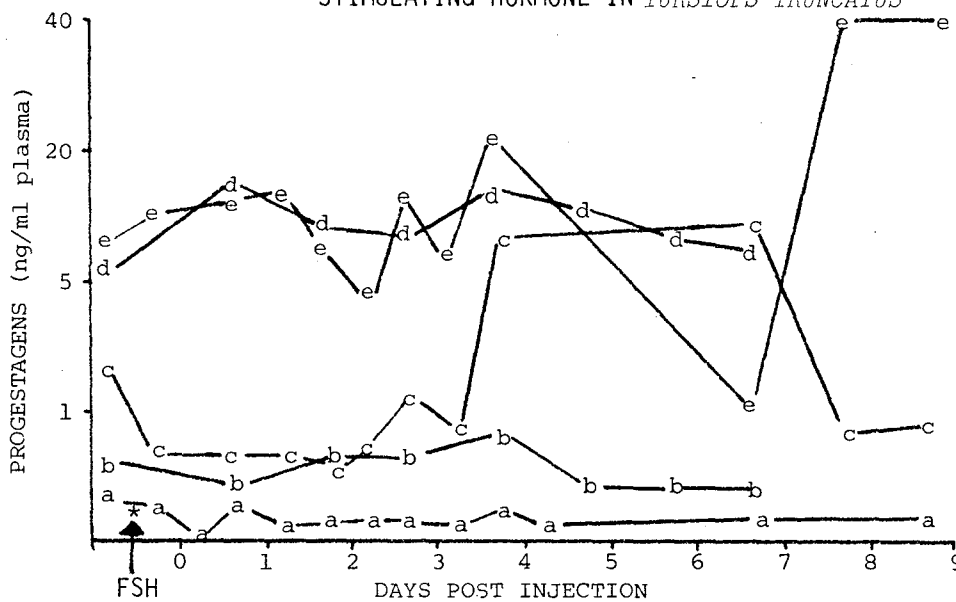


FIGURE 3: STEROID HORMONE PATTERNS AFTER THE INTRAVASCULAR INJECTION* OF 10 mg NIH-FSH-BOVINE-B-1 IN AN OVARECTOMIZED *TURSIOPS TRUNCATUS*

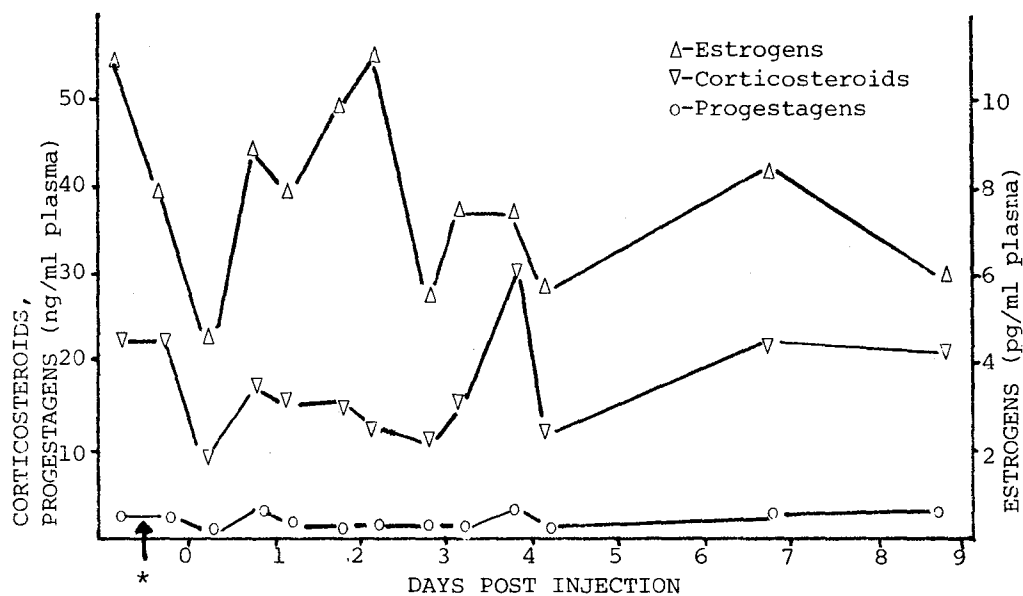


FIGURE 4: STEROID HORMONE PATTERNS AFTER THE INTRAVASCULAR INJECTION* OF 10 mg NIH-FSH-OVINE-S9 IN *TURSIOPS TRUNCATUS* DURING A NONGRAVID STATE

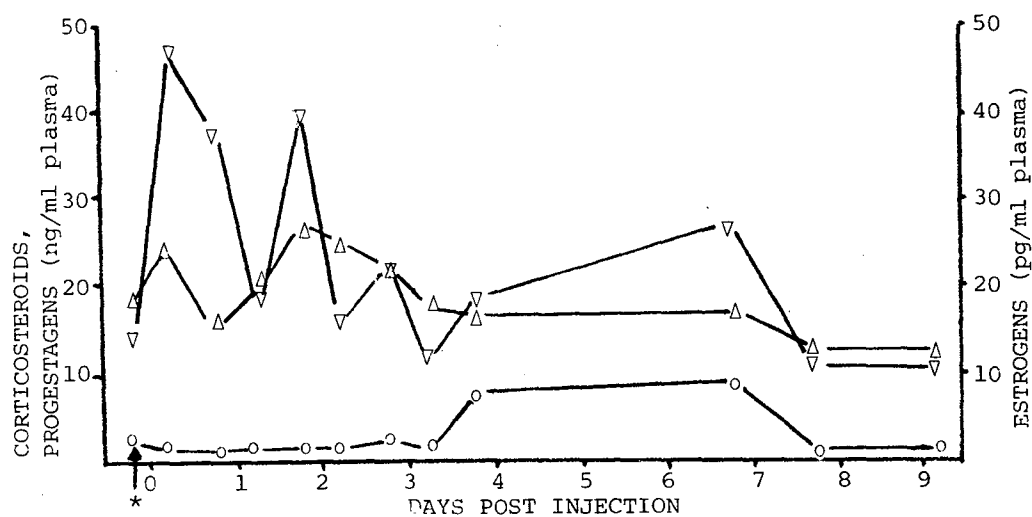


FIGURE 5: STEROID HORMONE PATTERNS AFTER THE INTRAMUSCULAR INJECTION* OF 10 mg NIH-FSH-OVINE-S9 IN *TURSIOPS TRUNCATUS* DURING THE SIXTH MONTH OF GESTATION

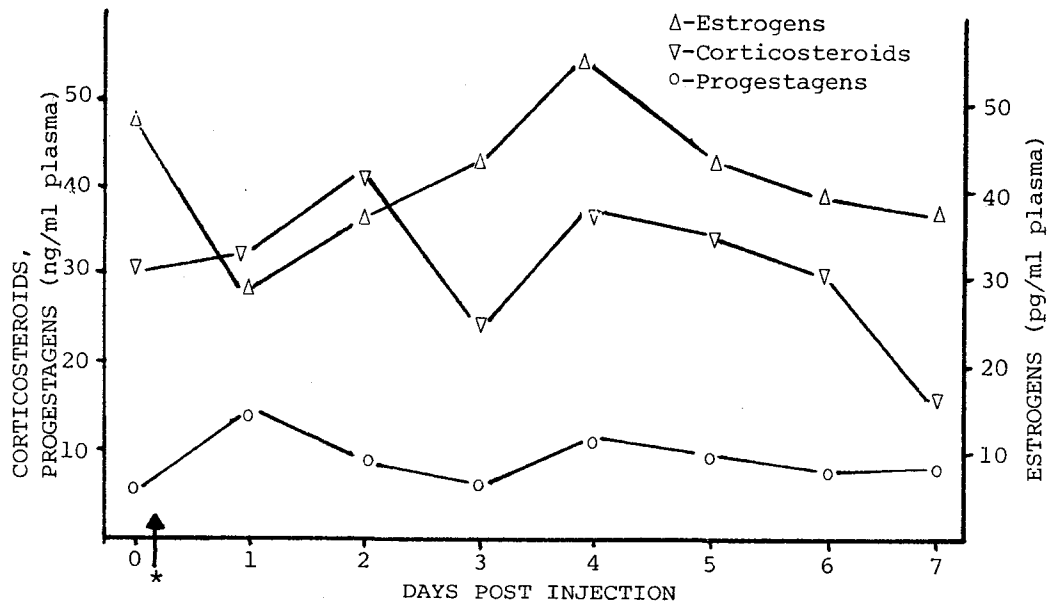
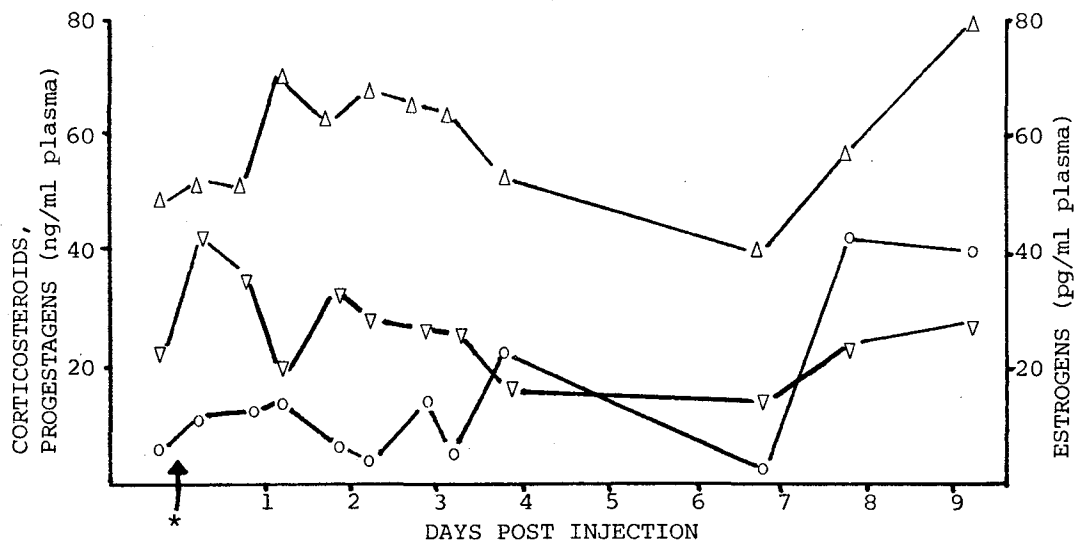


FIGURE 6: STEROID HORMONE PATTERNS AFTER THE INTRAMUSCULAR INJECTION* OF 10 mg NIH-FSH-OVINE-S9 IN *TURSIOPS TRUNCATUS* DURING THE NINTH MONTH OF GESTATION



TWENTY-FOUR HOUR PATTERNS OF CIRCULATING
ANDROGENS AND CORTISOL IN MALE DOLPHINS

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Some controversy exists concerning whether there is an annual rut or period of increased sexual activity in male cetaceans (Slijper, 1962; Asdell, 1964; Ridgway and Green, 1967; Harrison *et al.*, 1972). There is also a lack of knowledge concerning the criteria for determining sexual maturity in male dolphins. Some serum testosterone levels from immature *Tursiops truncatus* and one mature animal of the same species were presented by Harrison and Ridgway (1971). Several captive *T. truncatus* males under eleven years of age had testosterone levels similar to those of human males before puberty. One mature male was sampled at about monthly intervals for a 24 month period, March 1969 through February 1971. Plasma levels in this animal were much higher like those in other mature mammals. The highest levels were found in the fall of the first year (September and October), and the following spring (April and May). During the subsequent fall the levels did not rise but did increase the next January and February.

A potential problem exists when animals are sampled at infrequent intervals (monthly) to determine possible seasonal variation of circulating testosterone levels. The concentration of this androgen is not steady but may fluctuate significantly over short periods of time. These ultradian (less than one day) fluctuations of testosterone may be profound in some animals (bovine) (Katongole *et al.*, 1971) while they are of less magnitude in other mammals (man) (Naftolin *et al.*, 1973). In addition, testosterone has been shown to have a diurnal rhythm (highest at night and in the morning) as shown by most studies in humans (Judd *et al.*, 1973) as well as monkeys (Goodman *et al.*, 1974). If profound ultradian and or diurnal fluctuation of testosterone exists in dolphins,

monthly sampling would be useless in the investigation of a possible annual rhythm. In addition, if there is a great daily variation, several samples would need to be taken at various times during the day to make meaningful correlations of serum testosterone levels for the purpose of sexual maturity determination.

To examine the possibility of ultradian and/or diurnal fluctuations of testosterone in dolphins we sampled 2 male dolphins at intervals of twenty minutes throughout a twenty-four hour period.

MATERIALS AND METHODS

Two male dolphins were available for these studies. Maui was a 19 year old Atlantic bottlenosed and Ivan was a 7 year old Pacific bottlenosed. Maui had been in captivity for over 13 years and Ivan for about five years. The age of both animals had been determined by extracting a tooth and sectioning it (Sergeant *et al.*, 1973; Ridgway *et al.*, 1975).

The animals were removed from the water and placed in transport slings. Each was laid on a foam rubber pad and an intravenous catheter was put into the brachiocephalic vein through a needle inserted at the midline on a plane intersecting the anterior insertion of the flipper. After the catheter was inserted the animals were picked up in the sling and placed in a transport container where they rested on foam rubber that had been cut out so that the flippers could hang downward. The container was then filled with water up to the animal's eye level. All parts of the animal that were out of water were sprayed continuously to keep them moist and cool. The catheter was long enough so that the tip, which was built to take the hub of a syringe, could be placed on the animal's back. Blood samples were collected at the start of the experiment at 0800 one morning and every 20 minutes thereafter until the next morning at 0800. After each blood sample was drawn, heparinized saline was used to flush the catheter. Before the next sample was obtained, three ml of fluid were aspirated from the tubing to insure the next blood sample would not be diluted with the heparinized saline solution. Blood samples were centrifuged immediately after they were drawn and stored in a freezer.

The procedure we employed to maintain the animals in the transport container has been used many times without noticeable ill effect on dolphins (Ridgway, 1972). Although both of these animals had been transported previously in transport slings this was their first exposure to this particular experimental situation. Each showed some signs of restlessness during the experimental period but both were fine and took food when placed back in the water after the experiment.

Serum testosterone (T), androstenedione (Δ), dehydroepiandrosterone (DHEA), and cortisol were measured on each sample by previously described radioimmunoassay procedures (Judd *et al.*, 1973; Judd and Yen, 1973a; Hopper and Yen, 1975).

RESULTS

Figure 1 shows the levels of the three androgens and cortisol in Maui. At the beginning of sampling the plasma testosterone level was 5206 pg/ml. There was a steady decline in the circulating level of this hormone for the remainder of the study with the levels reaching a nadir of 1345 pg/ml at the end of sampling. Minimal, if any, pulsatile activity was observed. Androstenedione levels were also highest at the beginning of sampling (1536 pg/ml), and showed a similar pattern of decline through the entire study reaching a nadir of 263 pg/ml. Again, minimal, if any, pulsatile activity was observed. Dehydroepiandrosterone levels were at or below the level of detectability in the majority of samples, with the highest levels being observed after 2200 hours. Cortisol levels were below 50 ng/ml until 1800 hours. Periodic fluctuations of this hormone were observed during the remainder of the study with the highest levels being 160 ng/ml. In general, the fluctuations of cortisol did not coincide with those seen for dehydroepiandrosterone.

Figure 2 shows the concentrations of the same hormones found in Ivan. Testosterone levels were considerably lower in this dolphin with the highest level being 842 pg/ml. Testosterone levels remained low for the entire study and showed minimal pulsatile activity. Androstenedione levels were also lower in Ivan with the highest concentration of 850 pg/ml being observed at the beginning of sampling. During the first 4 hours of

sampling there was a gradual fall of androstenedione to the 400 pg/ml range where it remained for the balance of the study. Minimal, if any, pulsatile activity was observed. For dehydroepiandrosterone the levels were higher than in Maui and ranged between 642 and 2391 pg/ml. Some pulsatile fluctuations were observed particularly after 1800 hours. Cortisol levels were at or below 50 ng/ml until 1800 hours. After 1800 hours there was a continual rise in the concentration of this hormone reaching its highest level of 380 ng/ml at the end of the study. Except for one pulsatile burst, minimal pulsatile activity was observed.

DISCUSSION

The purpose of this study was to determine if ultradian and or diurnal fluctuations of circulating testosterone are present in male dolphins. Maui was 19 years of age and was presumed to be sexually mature although he had not bred. His initial testosterone level of 5206 pg/ml was similar to the levels reported earlier for a dolphin known to have impregnated a female (Harrison and Ridgway, 1971). It was also within the range reported earlier for other mature mammals. Ivan was 7 years of age and was possibly sexually mature. However, his testosterone levels were within the range reported for sexually immature dolphins (Harrison and Ridgway, 1971). In both dolphins, ultradian and diurnal fluctuations of testosterone were not seen. However, a steady decline of testosterone was observed in Maui. This raises the question if whether the stress of the study may have affected the testicular secretion of testosterone. In humans, the stress associated with non-gonadal surgery has been shown to have an effect on testicular testosterone secretion (Aono et al., 1972). If the stress associated with this study affected testicular androgen secretion it may have blocked any ultradian or diurnal fluctuations of this androgen in addition to causing a fall in the circulating level.

In both animals there was a fall in the concentration of androstenedione. This androgen has been shown to be the secretory product of the testis as well as the adrenals (Dorfman and Shipley, 1956). The fall in both animals may also reflect decreased testicular secretion.

Some pulsatile activity was observed for cortisol, particularly at night. In addition, cortisol levels were higher at night than during the day. Thus, the diurnal rhythm of cortisol appears to be present in dolphins.

In summary, ultradian and diurnal fluctuations of circulating testosterone were not found in two male dolphins sampled every 20 minutes for 24 hours. The steady decrease of testosterone in one of the animals suggested that the test situation may have been too stressful to obtain physiological data. We plan to develop a test procedure that is less stressful and repeat the experiment. The animals will be exposed to the test situation several times so that they are adapted and therefore under less stress before the study is repeated.

ACKNOWLEDGEMENTS

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FIGURE 1: 24 HOUR PATTERNS OF CIRCULATING TESTOSTERONE, ANDROSTENEDIONE, DEHYDROEPIANDROSTERONE (DHEA), AND CORTISOL IN A 19 YEAR OLD ATLANTIC BOTTLE-NOSED DOLPHIN.

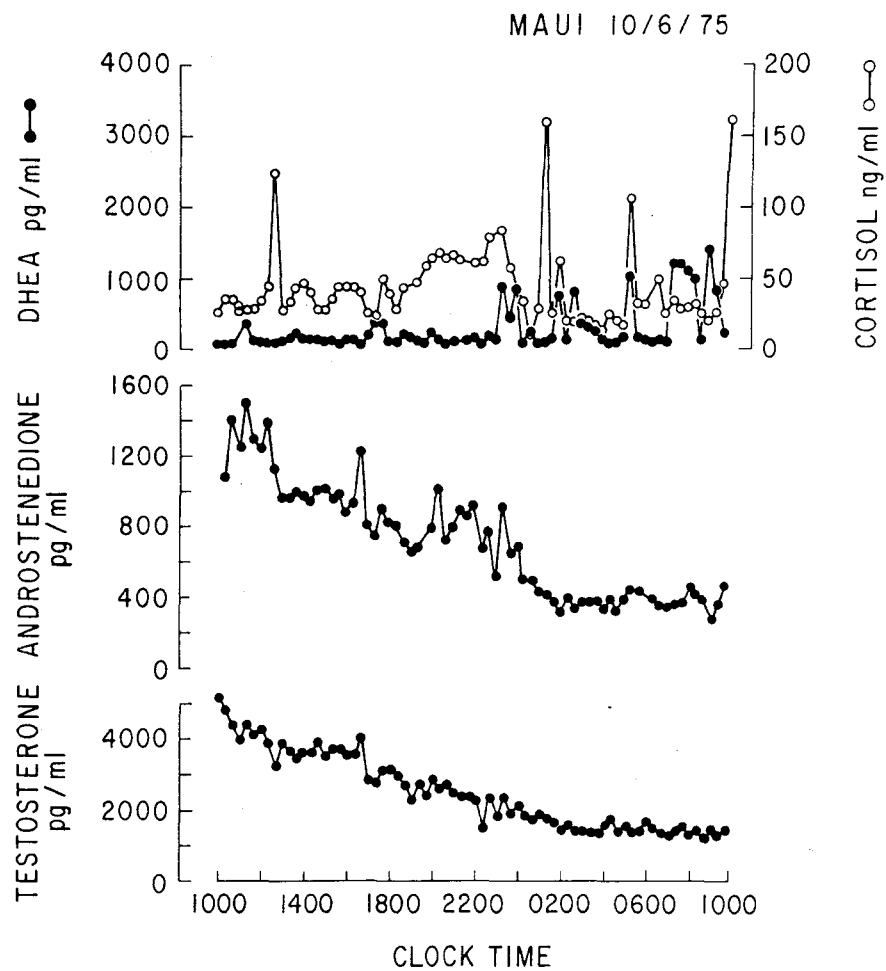
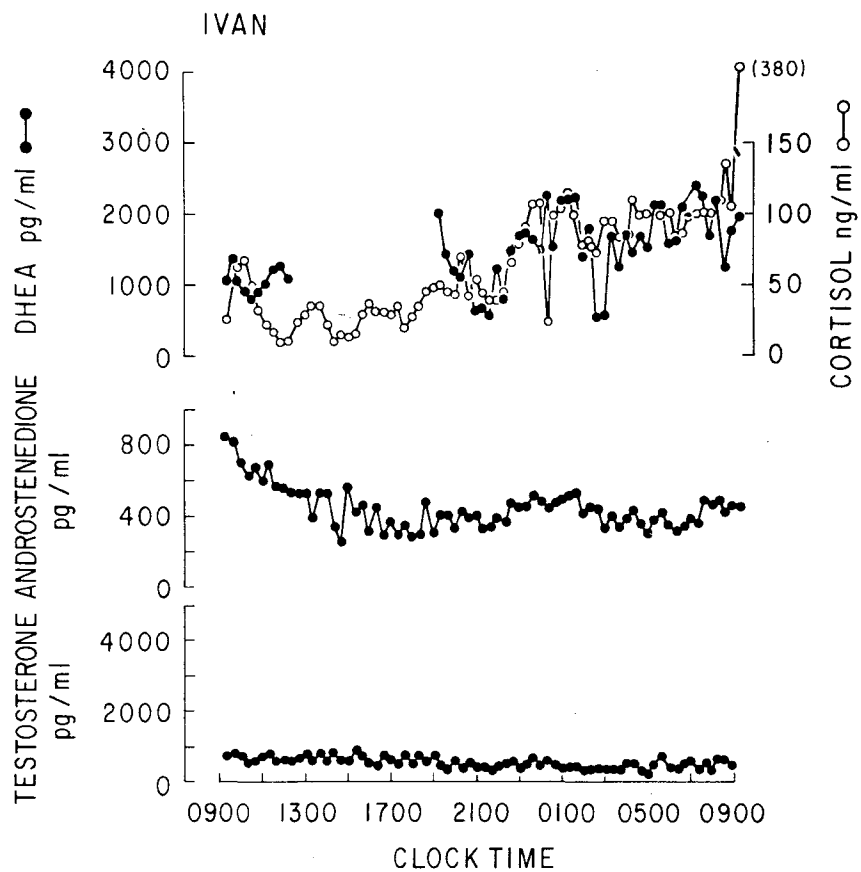


FIGURE 2: 24 HOUR PATTERNS OF CIRCULATING ANDROGENS AND CORTISOL IN A 7 YEAR OLD PACIFIC BOTTLENOSED DOLPHIN.



DIFFICULT BIRTHS AND NEONATAL HEALTH
PROBLEMS IN SMALL CETACEANS

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INTRODUCTION

While almost 150 births of *Tursiops* have occurred in captivity since 1940, there have been few direct attempts to establish dolphin breeding programs. Most of the *Tursiops* births have occurred incidental to the daily operation of oceanaria. Federal legislation and the increased cost of animal collection have sparked much greater interest in developing a successful program to reproduce and raise dolphins in captivity. With the intent of learning from experiences and statistics from the past, this paper surveys *Tursiops* breeding and calf-rearing records derived from information kindly made available to me from various organizations, including Marineland of Florida, Miami Seaquarium, Marineland of the Pacific, Sea World, Inc. of San Diego, Sea Life Park of Hawaii and the Naval Undersea Center. Over one-half of all dolphin birth records come from these groups.

DIFFICULT BIRTHS

A considerable percentage of *Tursiops* pregnancies in captivity have resulted in abortions or stillbirths. Some of these fetal deaths occurred during difficult parturition; others resulted from either maternal or fetal health maladies.

Stillbirths

From Table 1 it is apparent that 31% of all *Tursiops* pregnancies in captivity have resulted in stillborn calves, most having occurred at full term of gestation. Records of stillbirths are sketchy, yet from Table 2, there can be little doubt that stillbirths are more prevalent

among recently captured cows who conceived in the wild. High stillbirth rates are not, however, limited to ocean bred animals. Oceanarium A, which has had the greatest number of pregnancies and historically the most "natural" social and spatial environment, has also recorded the greatest percentage of stillbirths.

Dystocias

From data provided by Marineland of Florida, parturitions resulting in live-born calves took significantly less time than those resulting in stillbirths (Figure 1). Eleven live births had a mean parturition time of 54 minutes (maximum time 117 minutes and minimum time 21 minutes). Nine stillbirths had a mean parturition time of 240 minutes (maximum time 567 minutes and minimum time 20 minutes). It is not known whether the prolonged delivery time was due to the presence of a dead fetus or whether the fetus died because of the prolonged labor due to some maternal factor.

At least two dystocias have resulted in maternal death: one *Tursiops* had a malpositioned dead fetus, and a beluga whale had severe hepatic necrosis. In both cases, the mothers might have survived had a fetal viability test been performed. There is still considerable ignorance about the labor process. The only publication on the subject is that of Essapian (1963) who made behavioral observations of the labor process.

NEONATAL HEALTH PROBLEMS

As shown in Table 1, 51% of the live-born *Tursiops* calves, in 6 oceanaria from which data was made available, survived to an age of one year. Again, though records covering neonatal mortalities are grossly incomplete, it appears that factors affecting longevity can be grouped in 3 general categories: environment, neonate age and exogenous manipulation.

Environment

Table 2 represents the experiences of 6 oceanariums. Oceanariums A and B are older facilities with most of their breeding and calving occurring in very large tanks containing a rather stable social group. In terms of survival of calves to one year, these two establishments have

had somewhat better success, viz., 59% and 61% in comparison to roughly 36% for the combined totals of the others. In oceanariums C-F the majority of the breeding experiences have been in smaller pools. This implies that there is an environmental factor in the larger enclosures which accounts partly for the better record. Certainly the presence of a stable social group with ample environmental space might provide a more secure psychological sense of well-being. The larger enclosures better enable the mother and calf to avoid or escape physical interactions with other animals, if necessary. Disturbances from people and activities outside the pool are also reduced in the larger systems. In Oceanarium B, mortalities in the first year of life have increased since 1966 to 64% of all live births. No explanation for this has been given but one might speculate on the role of overcrowding, increased performance demands, reduced water quality in an aging system, increased manipulative situations, changes in social structure or perhaps even better record keeping.

Neonate Age

From Table 2 it is obvious that within the first year, mortalities are much more probable in the first 6 months, e.g., 32% of live births died prior to 6 months and 17% died in the period between 6 and 12 months. As shown in Figure 2, 14 of 60, or 23%, died before one month, while following this period, mortality leveled off at about 2% per month. It is apparent, therefore, that almost half of the high infant mortality occurred within the first few weeks of life.

Observations on many of the newborn mortalities suggest that most of these occurred as a result of aberrant behavior between dam and offspring. Poor suckling habits or the absence of milk, and injury to the infant by the dam or occasionally other dolphins are commonly reported. One might attribute such behavior to environmental problems discussed previously. There is some speculation that first-time mothers are more apt to be unsuccessful, although the observations are certainly not consistent.

Mortalities in the older infants, i.e., aged 1 month to 1 year, appear to occur as a result of a variety of problems. Autopsy reports

are scanty, but certainly a number of deaths are caused by overwhelming infection. Early infant mortalities at Marineland of Florida were attributed to erysipelas infections (Wood, this volume).

Manipulation

It is difficult to quantify the effect of stress in cetaceans, but there appears to be some positive correlation between the handling of infants and infant mortalities. On numerous occasions, well-intended attempts at handling, examining, or moving infants have apparently resulted directly in the infant's death. While there appear to be no sex differences in infant mortalities (see Table 2), enough experience has been gained to state that under conditions of physical manipulation, such as restraint, male calves have a much higher tendency to fall into "capture shock" than females. It would appear that infants under 1 year of age should be handled with extreme caution.

CONCLUSIONS AND RECOMMENDATIONS

A historical review of *Tursiops* births in captivity has shown a high incidence of fetal and infant mortality, with implications that this high death rate could be significantly reduced. Parturition times should be closely monitored, and if birth has not occurred after 150 minutes, chemical or surgical intervention is indicated. Such a decision is of course, dependent upon accurate identification of the onset of labor. Since ocean-bred animals have had a higher incidence of dead offspring, animals known to be pregnant should not be captured (a requirement of current law). By providing adequate environments, suitable social groups and a general "hands off" policy, the loss of infants, particularly those in the first month of life, might be reduced.

In husbandry of any breeding colony the maintenance of good health in the pregnant and lactating cow, as well as in companion animals, is extremely important. No successful breeding program can be initiated without first assuring, as much as is possible, the proper health of the breeding stock.

ACKNOWLEDGEMENTS

The author wishes to thank those six oceanariums which kindly provided data from which much of this paper was derived.

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TABLE 1: SUMMARY OF NEONATE LONGEVITY WITHIN SIX AMERICAN OCEANARIA

OCEANARIUM	TOTAL BIRTHS	LIVE BIRTHS	% OF TOTAL BIRTHS	SURVIVE 1 YEAR	% LIVE BIRTHS SURVIVE 1 YEAR	SURVIVAL OF TOTAL BIRTHS BEYOND 1 YR.	% OF TOTAL BIRTHS SURVIVE BEYOND 1 YR.
A	40	22	55	13	59	13	32.5
B	23	18	78	11	61	11	48
C	8	8	100	3	38	3	38
D	7	6	86	1	17	1	14
E	4	2	50	1	50	1	25
F	6	5	83	2	40	2	33
TOTAL	88	61	69	31	51	31	35

TABLE 2: MORTALITIES (UNDER AGE 1 YEAR)

OCEANARIUM	A	B	C
TOTAL BIRTHS	40	23	6
DEATHS	27	12	3
% OF TOTAL	67.5	52	50
BORN DEAD	18	5	0
% OF TOTAL	45	22	
CAPTIVE BRED	12 of 30 (40%)	3 of 15 (20%)	
OCEAN BRED	6 of 10 (60%)	2 of 8 (25%)	
BORN ALIVE	22	18	6
% OF TOTAL	55	78	100
LIVE < 6 MO.	7 (32%)	4 (22%)	2 (33%)
LIVE 6 MO. TO 1 YR.	2 (9%)	3 (17%)	1 (17%)
SEX RATIO			
MALE	12	8	3
FEMALE	10	9	2
MALE DEATHS	4 (33%)	4 (50%)	1 (20%)
FEMALE DEATHS	5 (50%)	2 (22%)	2 (40%)

Table 2 (cont.)

OCEANARIUM	D		E		F	
TOTAL BIRTHS	7		4		6	
DEATHS	6		3		4	
% OF TOTAL	82		75		66	
BORN DEAD	1		2		1	
% OF TOTAL	14		50		17	
CAPTIVE BRED	1 of	6 (17%)	2 of	4 (50%)	1 of	4 (25%)
OCEAN BRED	0 of	1 (0%)	0 of	0 (0%)	0 of	2 (0%)
BORN ALIVE	6		2		5	
% OF TOTAL	86		50		83	
LIVE < 6 MO.	4	(66%)	1	(50%)	3	(60%)
LIVE 6 MO. TO 1 YR.	2	(32%)	0	(0%)	0	(0%)
SEX RATIO	Insufficient data					
MALE	5		2			
FEMALE	1		0			
MALE DEATHS	4	(80%)	1	(50%)		
FEMALE DEATHS	1	(100%)	0	(0%)		

FIGURE 1: PARTURITION TIME IN *TURSIOPS* :
LIVE VS. STILLBORN

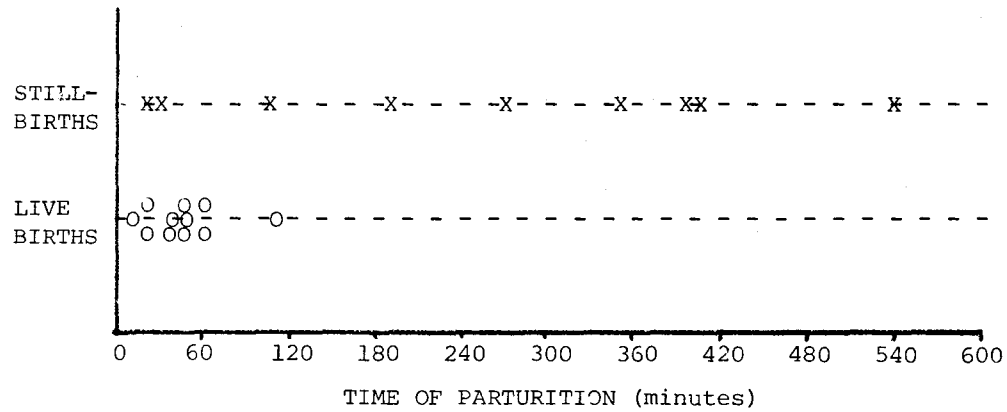
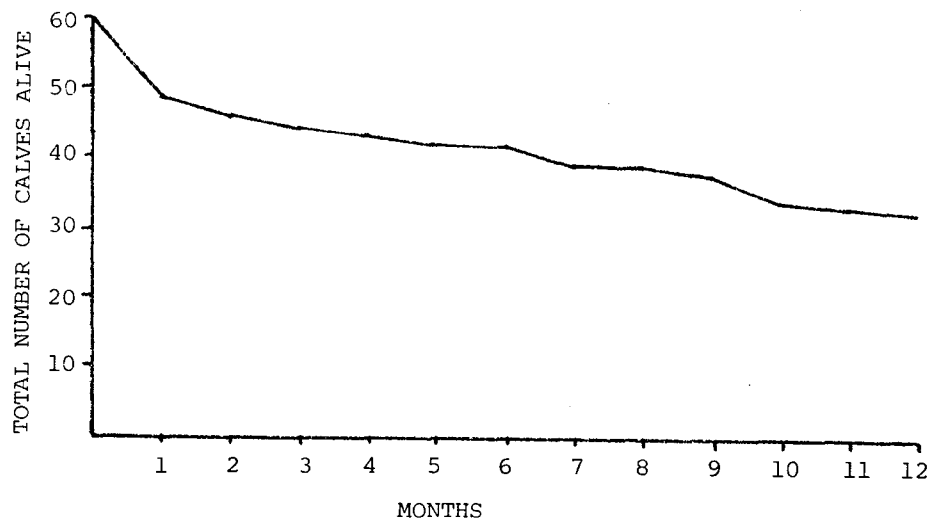


FIGURE 2: NEONATAL MORTALITY VS. TIME



THE SAIGA - A PROBLEMATIC UNGULATE
UNDER CAPTIVE CONDITIONS

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Ungulates have a long history of captive propagation dating back to the 9th to 7th centuries B.C. when the process of domestication was begun. Despite this fact, two genera stand out as problematic forms under captive conditions outside of their natural areas of distribution, the pronghorn (*Antilocapra*) and the saiga (*Saiga*).

The saiga is often referred to as an antelope, which it is not. Rather, with its cousin the chiru or orongo, *Pantholops hodgsoni* (Abel, 1926) of the Tibetan plateau, it forms a special tribe, the saigini, in the subfamily caprinae or goatlike animals. Morphologically, the saiga and chiru provide a more basic bridge between the antelopes and the goats than do the rupicaprines or goat-antelopes. Little is known concerning the origin of *Saiga* and *Pantholops*, but because of their morphological, ecological and geographic specializations, which make them peculiar even within their own subfamily, it would appear that both genera have followed an independent course of evolution since the late miocene or early pliocene.

An adult male Russian saiga, *Saiga tatarica tatarica*, (Linne, 1766) stands approximately 76 cm at the withers, females being slightly smaller. In summer, the color is dull yellowish with a whitish throat and indistinct facial markings. In winter, this changes to a nearly uniform whitish color all over the body, without any markings. The ears are short and thickly haired. The short tail is the same color as the body. Only the males carry horns which are ringed, 33-36 cm long, and of a peculiar waxy amber color. The Mongolian subspecies, *Saiga T. mongolica*, (Bannicov, 1946) is an isolated juvenile population, smaller in size and of a sandy gray color with a clearly defined brown spot on the croup. The most characteristic feature of the saiga is the large, elongated nose which

is bent downwards and inflated. The nostrils open downward. During the rut, the male's nose increases in size, producing a distinct ridge on the dorsal surface. In the Mongolian subspecies, the bulbous nose is less highly developed. The function of the enlarged nose is not understood.

The saiga has been known in the European literature since the first century, A.D. Strabonis, reporting on the land of the Scythians and Sarmatians in his *Perum Geographicum*, tells us the following:

Among the four-footed animals there occurs the so-called 'Kolos', which is between a deer and a sheep in size, of a white pelage and faster than either a deer or a sheep; when drinking, water is drawn into the head through the nose where it is stored, so that it can live in water-less regions...

During the pleistocene, the saiga occupied a vast range extending from England across central and western Europe, east in Siberia as far as the mouth of the Jana River and the New Siberian Islands. Recent fossil finds have shown the saiga to have been a contemporary of the woolly mammoth in Alaska. It is interesting to note that the fossil pleistocene saigas are considered to belong to the same species as the living animal. In recent times the Russian saiga was confined between the foothills of the Carpathian Mountains and the foothills of the Altai. A second subspecies, the Mongolian saiga is native to the Dzungarian Gobi and the western portion of the Mongolian People's Republic. The two subspecies are separated from each other by the Mongolian Altai.

In the last 30 years, the saiga has become one of the most common wild ungulates in the Soviet Union. Prior to this it was in danger of extinction. Information concerning its abundance in the 19th century and its decline during the 1930's is very sparse. General works published in the 18th and 19th centuries would indicate that the saiga was a very common animal on the Russian Steppes. Pallas (1770) wrote that the saiga was very common along the Ural River and all areas not settled by the Kirghiz were full of saiga. In 1773, he wrote that the saiga was so common that his cossacks were able to shoot all they wanted. In the first half of the 19th century there was no appreciable reduction in numbers or habitat. However, in the second half of the 19th century

the tide turned and there was an enormous reduction not only in range but in numbers. At the beginning of the 1930's, there were only a few hundred saigas left in Kazakhstan and in the Dzungarian Gobi only a few dozen. Only on the western bank of the Volga were there any number of saigas remaining. Over the entire range there were probably no more than 1000 animals. At this point, the animal became protected game in the Soviet Union.

Over its entire range, the saiga is confined to pure steppe conditions, avoiding not only mountains but also areas of uneven topography. Normally, it will not even climb small grass-covered hills, such as sand dunes, although in winter it occurs in the hilly steppes as a protection against snow storms. The present range of the animal is confined to dry steppe and half deserts, where the complex plant association appears to provide the optimum conditions for the species. Thus, over a rather limited area, the saiga finds sufficient food throughout the year. The seasonal migration undertaken by the animals generally does not extend outside this region. Saigas are not bound to a specific area except during the short rutting and lambing period. Frequent herd movement from one area to another appears to be typical of the species.

The saiga is a polygamous animal with the height of the rut typified by the formation of harems. Mature males gather together groups of females and protect these from the advances of other mature males. The rut takes place in December with the large herds broken into small groups of one male and from 2 to 50 females. The savage fighting of the males for their harems often results in the death of one of the combatants.

The lambing season occurs in April and May, at which time the pregnant females gather in specific areas where they bear their young, usually the open steppe where grazing is poor. Older females normally produce twins; young females, a single lamb. After 48 hours, the lambs are able to run so rapidly that a man cannot overtake them on foot. They follow their mothers when grazing and can move from one area to another with the adult animals. However, they are still comparatively weak and spend a great deal of the time rolled up in the sun. When the lambs are four to five days old, they accompany their mothers the entire day, walking near them and playing.

Other than man, the chief enemy of the saiga is the wolf. The distribution of the wolf is correlated directly to the distribution of the saiga. Wolves are always more common on the summer and winter gathering grounds of the saigas. A single wolf cannot successfully hunt a strong adult animal, but males that have been weakened by the rut, pregnant females, and newborn lambs fall easy prey. In heavy snow, a lone wolf can also succeed in bringing down an adult saiga, as the weight of the saiga, which is 4.5 times that of an adult wolf, acts to its disadvantage. Normally the wolves hunt in packs, part of the group following the saigas and another portion cutting off the way of escape. It was calculated that in Kazakhstan wolves took between 20 to 25% of the population, primarily lambs and weakened males. With the reduction of the wolf population over the saigas' range, the saigas have increased proportionately.

Adult animals have no other natural enemies. However, ravens, golden eagles and tawny eagles will attack newborn lambs. The females attempt to protect their young from birds of prey by leaping into the air and trying to strike the birds with their heads and forelegs. This same defensive reflex has been initiated by low-flying aircraft.

Prior to the conclusion of the Second World War, the saiga was relatively uncommon in collections. The first example exhibited outside of Russia was a male presented to the London Zoological Society in 1864, the same year that the saiga was first exhibited in Moscow. Following this, specimens were to be seen in Berlin in 1872, Cologne in 1874, Hamburg in 1877, Antwerp in 1878, and Bremen in 1889. Longevities are not recorded for most of the 19th century animals with the exception of the pair received in Berlin in November of 1872. Of this pair, the male survived until the 12th of October 1875, the female until the 15 of October 1873. The largest single transport to be received in a collection was that of 19 animals which arrived at Woburn Abbey in 1906. The saiga had been previously imported by the Duke of Bedford in 1902 but without success. Of the 1906 group, 12 were born in the same year, but of the entire group only 3 remained alive by the end of the importation year. The causes of death were primarily traumatic and parasitic infection. Between 1900 and 1938 only about 8 animals reached Germany - some of

these being sent to the United States, a male arriving at the National Zoo in 1934, another male going to New York in 1936, and 4 animals to St. Louis between 1934 and 1937. The greatest longevity reached in New York was 2 years, 8 months and 18 days. The animal exhibited in the National Zoo lived for 4 years and 19 days, while a female in St. Louis lived slightly over 7 years. Between 1958 and 1972, 22 groups of saigas consisting of 143 animals were received in East Berlin. Of these, 87 were shipped abroad. It is from these importations that saigas found their way into U.S. collections at Albuquerque, Lincoln Park, Dallas, Omaha, Oklahoma City, Philadelphia, San Diego, San Francisco, and Toledo. Of the imported animals, only those in Dallas, San Francisco, Albuquerque and Oklahoma City bred. The majority of the saigas bred in the San Francisco Zoo terminated before they were one year of age as a result of trauma, the same being true for a number of animals bred in both Albuquerque and Oklahoma City.

In reviewing the history of saigas imported into the United States since 1958, we see that the primary causes of death were trauma and parasitism. Parasitism is a primary cause of death in wild saigas which are known to be infected by 32 species of nematodes and six species of cestodes. Furthermore, the known longevity for wild saigas under optimum conditions is relatively short, approximately 12 years, though few animals are known to reach this age in the Soviet Union.

Captive longevities fall short of those recorded for the wild, with the maximum being slightly over seven years.

It should also be remembered that the imported animals are generally taken as one- to two-day-old lambs, and hand raised, which makes them more susceptible to disease and environmental influences. Saigas also require a rather great flight distance when compared to other ungulates of their size.

At the present time, only one male and two female saigas remain in captivity in the United States. These three animals are at the San Diego Wild Animal Park and all are captive born. Unfortunately, this is a poor foundation for the establishment of a breeding stock.

In reviewing the history of these animals in captivity, certain recommendations for future maintenance become apparent. Saigas should be maintained in fairly large groups. Certainly more than a single pair, as the animal is gregarious in the wild. Furthermore, males become extremely aggressive during the rut. It is advisable that more than one female be present to prevent injury to a single estrus ewe. Under no circumstances should more than one adult male be permitted in a herd as this will often result in the death of an animal. Rutting male saigas have been known to kill females on numerous occasions, so that it may, in fact, be advisable to cap the horns of potential breeding males. A large enclosure appears to be a necessary factor - preferably moated to reduce the frequency of traumatic injuries. If fences must be used, they should have sight barriers to prevent the animals from crashing into them should they become frightened.

Unlike most ungulate enclosures, saiga exhibits should be designed to have greater depth than is generally provided because of their flight distance requirements. As in the case with wild sheep and goats, it is advisable that these animals be confined in dry, sandy enclosures to reduce the chances of parasitic infection to which they are highly susceptible.

As a closing thought, it would seem from the similarities which appear in the histories for the various collections that have maintained this animal, a greater effort must be made in sharing experiences by institutions that maintain difficult species.

CAPTIVE PROPAGATION OF THE AFRICAN CHEETAH,
(*ACINONYX JUBATUS*)

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The captive propagation of endangered or threatened species is desirable. The present world situation seems to indicate that captive propagation will become more commonplace and of significant importance. The wild and captive history of the cheetah seems to outline both the cause for pursuing a captive reproduction project, the methodology used, and its outcome and subsequent usage throughout the world.

The cheetah is an endangered species. Once having a distribution similar to the lion, its population is now severely reduced over its entire range. The animal is considered extinct in India. The animal has been hunted as game and for its pelage. The cheetah has been exported in large numbers for both the pet trade and for zoological parks. Land encroachment and destruction of prey animals have severely diminished the cheetah population. The early history of the cheetah in captivity was not encouraging. During the cheetah's long association with man spanning many centuries the animal had a poor survival record and extremely limited reproduction in captivity. The average longevity in captivity until 1960 was less than 5 years. It was not until 1956 at the Philadelphia Zoo that the first captive cheetah birth was recorded. Until May 1970 only 14 captive births were recorded to only 8 females.

The Donnor Foundation of New York in 1970 made available a grant to the Zoological Society of San Diego to study captive reproduction of cheetah at the San Diego Wild Animal Park.

Two 20,235 sq. meter pens, were constructed at the San Diego Wild Animal Park in an area inaccessible to the public. Galvanized 5 cm pipe fence posts, set in concrete, supported a 1.8 m chain link fence. The fence was topped with a .9 m chain link inrigger. To prevent the cheetahs

from digging under the fence, a .9 m width of stucco netting was attached to the bottom of the fence and anchored to the ground around the inside perimeter of the pens. A 9.1 sq. meter catch pen built in one corner of each enclosure was used as a feeding and trapping area. Each enclosure contained clumps of sumac, prickly pear cactus and other types of vegetation which provided natural shade and cover. Two portable open-faced plywood shelters were placed in each unit. A large tree stump scenting post was also made available in each pen.

The five pairs of adult, wild-caught cheetahs arrived at the San Diego Zoo on 28 May 1970. They were quarantined at the San Diego Zoo hospital. A complete examination of each animal was made while they were under Sernylan (Phencyclidine HCl) restraint. Each animal was sexed, weighed, measured, ear-tagged and tattooed, and vaccinated with duck embryo rabies vaccine, and tissue cultured panleucopenia vaccine. Blood was collected for hematological studies. Fecal examinations indicated that the animals had infestations of ascarids and tapeworms. Each cat received 1 ounce of Thiabendazol mixed with their food, to remove the ascarids. Before moving the cheetahs to the permanent pens at the Wild Animal Park, blood was again collected for panleucopenia antibody titers. The cheetahs were identified by color-numbered ear tags, photographs and names. The distribution of the animals in Pens 1 and 2, and their dates of arrival at the Park is presented in Table 1.

The initial enclosures (Figure 1) allowed observations of the two groups of cheetahs. Both enclosures were 20,235 sq. meters in size and provided a semi-natural environment. The cheetah diet consisted of a commercial homogenized diet, specifically developed for large, exotic felines, and fed at the rate of 1.8 kg/day, five days a week.

Initial observations of the two groups of cheetahs indicated that the animals integrated without problems and social interactions, other than mutual face-licking and minor play, were minimal.

COURTSHIP AND PREGNANCY - AUGUST 1970

On 6 August 1970, three females were actively courted by the two males. Figure 2 is a behavioral response flow chart indicating the generalized courtship behavior that occurred up to 30 August 1970.

During courtship, inter-male aggression increased, suggesting a struggle for male dominance. The intensity of male interest, and receptiveness of females, peaked on 20 August. Copulation was not observed. The courtship of Lonesome was particularly intense.

Pregnancy of female Lonesome was first suspected on 9 October 1970. At that time her abdomen appeared to be enlarged when in a sitting position, and her behavior seemed to be more timid. In the following weeks her conformation changed considerably; when sitting, the abdominal area bulged laterally. On 18 November, her teats were observed to be light in color and more readily discernible.

After a presumed normal gestation of 93-95 days, parturition occurred on 22 November 1970, between 0700-0900 hours. The selected nesting site was located on the far northwest hillside under a clump of sumac bush. The female and three cubs appeared healthy. Male, Blue, approached the hide at 1040 hours, and ate one of the youngsters. Before removal of the cubs could be accomplished a second cub was killed, but the third baby was retrieved.

CHEETAH HAND-RAISED

Juba, the surviving cub, a male, was taken to the Children's Zoo, for hand-rearing. The animal was placed in an incubator with 24-hour attendant supervision.

The cub weighed 589 gm and measured 35.6 cm. The milk formula used was: Modillac, distilled water, corn oil and casein powder, supplying 30 cal/ounce, 9% protein and 8% fat. His eyes opened on the 8th day, the incisors erupted on the 13th day, and solid food was taken on the 44th day. Juba died on 19 July 1972, at the San Diego Zoo, at the age of 1 year and 8 months, from anemia due to a severe infestation of fleas, contracted after being moved to the cheetah pens. Juba was the first captive-born cheetah in the United States to live longer than 2.5 months.

The initial breeding success following introductions of males and females, and later observations, strongly suggested that continual male and female association may inhibit normal sexual behavior by an habituated process. Constant male and female exposure may alter the sexual

response and suppress the development of sexual motivation. Eaton, Schaller, and others, indicated males were not found accompanying animals in the wild; and females were usually alone or with cubs. The initial breeding success and subsequent cessation of activity strongly suggested that initial integration of the males and females motivated the group to breeding, but subsequent continual integration interfered with normal reproductive behavior.

Other behavioral data had suggested several possibilities for management changes which might encourage reproductive behavior.

Sexual behavior in other cheetahs during 1972 had not altogether ceased but appeared suboptimal. Pen 1 was designated as the male pen and Pen 3 the female pen. Pen 2 was used as a buffer zone to minimize male-female contact visually, olfactorily and tactily. A maternity pen was constructed in June 1972 and Lonesome and her three female cubs were moved to the new pen so that both pens 2 and 3 could be used for male introductions in August.

Observations of courting males indicated that the presence of several females, either in the same pen or in a pen sharing a common fenceline, could "sidetrack" them and discourage active courtship of a single female. Male efforts to arouse a female seemed more likely if pursuing males concentrated on a single receptive female.

In March 1973, pen 2 was divided into two pens, 2A and 2B, by constructing a diagonal alleyway between the catch pens of pen 2 and pen 3. The alleyway provided flexibility and ease in transferring males to pen 2A or B, and also pen 3. Further, the pen modification provided four pens for breeding purposes. Pen 2A and B, and the maternity pen, could be used for isolated female breeding experiments, while pen 3 was used to hold two or more females for comparative breeding studies.

COURTSHIP AND PREGNANCY - AUGUST, SEPTEMBER 1973

During August-September 1973, reproductive behavior was observed at the facility, after introduction of males. Generally the behavior appeared similar to previous introductions. Initial response by males to females was encouraging, but not necessarily long lasting. Previous

data suggested males may initially respond to females, but the behavior may last only 24 hours. The "male introductory syndrome" does not necessarily indicate the estrual state of the female. A male rotational scheme was developed; males were introduced to females in groups of two or three. Males were removed when interest in females waned, and a new group of males was added.

The male rotation appears to encourage male dominance behavior, modify existing social groupings, discourage male-female habituation, allow for possible mate preference and provides stimulus for continued sexual interest. The almost constant male interest may help in motivating females to "standing estrus".

Male aggression towards other courting males may play an important part in encouraging a female to true estrus. Observations made in captivity indicate male interaction increases during proestrus, peaks at probably estrus and then falls off. The possible importance of male vocalizations and interactions may be illustrated by the fact that Herdman played tape recordings of courting males, including vocalizations between males and females, which, when played back to a group of sexually inactive cats, seemed to initiate courting vocalizations and smelling of the female genitalia by males.

The behavioral data collected during the cheetah project has provided a general outline for captive management that encourages reproduction in the species. The following parameters are listed to provide a framework for continued research or simply as guidelines for those exhibiting or in possession of cheetah:

1. Male and female cheetahs become habituated to one another when kept together. The result is lack of sexual interest. Keep males and females separated until time of integration.
2. Male and female integration should be carried out in July-August and December-January. The female cheetah is apparently seasonally polyestrus.
3. Introduction of more than a single male to a female may be beneficial. Male rotation may encourage female to standing estrus.

4. A mate selective process has been observed periodically. Try several males to each female.
5. Courtship is more successful if male group is integrated with a single female.

The cheetah reproduction project during the last four years has gleaned a great deal of information. General husbandry and social management programs have been developed which encourage captive reproduction of the cheetah. Six litters have been born at the research facility from three different females. There have been 25 cubs born and 20 raised successfully. Captive births throughout the world since 1971 have increased substantially. A total of approximately 40 births have occurred with an excellent survival rate in the young.

The zoological community has for many years recognized the plight of the cheetah. They were also aware of the captive history of the cheetah. The general concern brought about an unparalleled concentration of effort in trying to solve the captive cheetah breeding problem. Throughout the world research began on this animal. In less than four years the fruits of many people's efforts can be seen. The captive cheetah population is apparently secure.

I would hope the success with the cheetah would encourage others to initiate world-wide programs with similar goals.

TABLE 1: DATES OF ARRIVAL AND DISTRIBUTION
OF CHEETAHS IN TWO PERMANENT PENS

PEN 1				PEN 2			
DATE	EAR TAG	NAME	SEX	DATE	EAR TAG	NAME	SEX
16-6-70	Yellow 61	Squeaker	M	5-6-70	Blue 44	Mr. Blue	M
16-6-70	Yellow 71	Miss Yellow	F	5-6-70	Green 284	Tuffy	F
16-6-70	White 85	Miss White	F	11-6-70	White 88	Herme	M
18-6-70	Yellow 62	Blackfoot	M	11-6-70	Green 285	Mr. Green	M
18-6-70	Blue 43	Cutie	F	11-6-70	Yellow 60 rt. White 97 lt.	Lonesome	F

TABLE 2: SEX, WEIGHT AND BODY MEASUREMENTS OF CHEETAHS
USED IN THE SAN DIEGO ZOO RESEARCH PROJECT

SEX	WEIGHT (kg)	RIGHT HIND FOOT (cm)	LENGTH OF BODY (cm)	TAIL LENGTH (cm)	RIGHT FRONT PAD (cm)
male	47.3	31.8	134	78.7	8.3
male	48.6	28.6	126.4	77.5	8.9
male	48.9	30.5	125.7	71.1	8.9
male	43.6	29.2	130.8	81.3	8.3
male	48.9	29.2	129.5	76.2	---
female	40.9	28.6	125.1	68.6	8.3
female	42.7	29.8	121.9	66.0	7.6
female	34.1	28.6	119.4	64.8	8.3
female	38.2	27.3	129.5	73.7	8.3
female	38.6	28.6	122.6	67.3	8.3

FIGURE 1: PLAN OF CHEETAH PENS AT SAN DIEGO WILD ANIMAL PARK

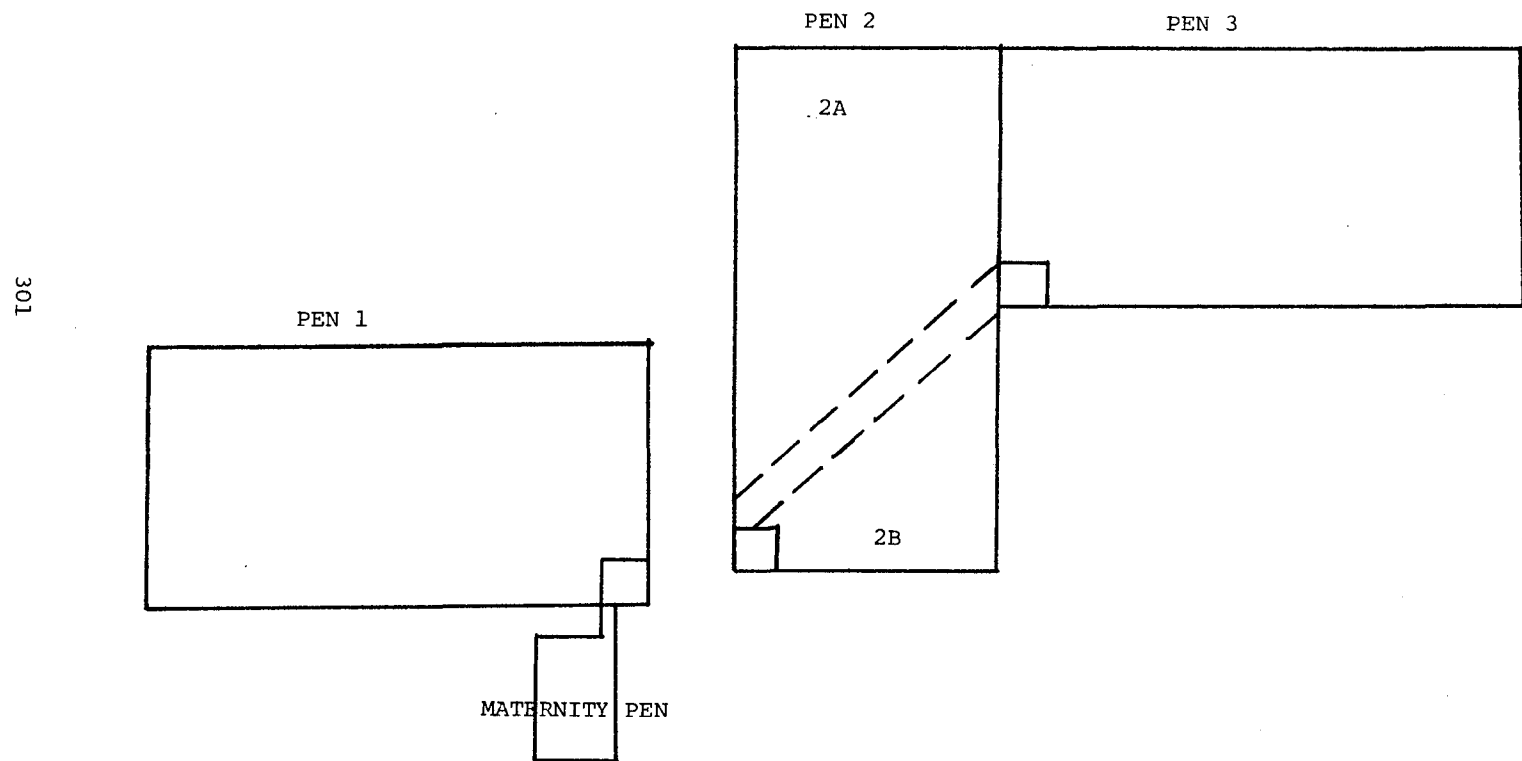


FIGURE 2: REPRODUCTIVE BEHAVIORAL RESPONSE CHART IN
THE AFRICAN CHEETAH (*ACINONYX JUBATUS*)

BASED ON OBSERVATIONS AT THE SAN DIEGO WILD ANIMAL PARK

<u>FEMALES</u>		<u>MALES</u>
No interest in males. No vocalizations.		No interest in females. No vocalizations.
	METESTRUS	
Stutter calls.		Minor following behavior (usually only single male). End of male fights.
Post copulatory fight.		Post copulatory fight (brief) with female.
	ESTRUS	
Running-stop-sternal recumbancy- male mounts; or circled by males and submits.		Neck bite. Copulation: rape or submission. One or more males chasing female, or mutual grooming with female
	PROESTRUS	
Female allows males to lick anogenital area.		Male fighting continues. Attempted mounts.
Tail twitching-pausing and looking back at males.		Lead male closest to female. Male dominance is variable.
Stutter calls, chirps, female slapping and lunging at males.		Intense smelling of vaginal discharge. Male fights increase.
		Active following female (head outstretched at female genital level), 1-2 m from female.
		Lead male established.
		Decline of scenting activity.
		Males fighting over female.
		*Male introductory syndrome possible.
Apparent vaginal discharge, stutter calls, high chirps.		Following behavior: moans, chirps, stutter calls, erections. Pen exploration and scenting behavior (vehement tail twitching during scenting).
	SEPARATION ——— INTEGRATION ——— SEPARATION	

*Following behavior occurring shortly after male introduction lasting less
than 48 hours.

INBREEDING DEPRESSION: WILL IT BE A PROBLEM
IN THE CAPTIVE BREEDING OF DELPHINIDS?

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Inbreeding is the mating of close relatives and the concomitant loss of heterozygosity in the offspring. The seriousness of the effects of inbreeding depend on the genetic load in the population, or the average number of "bad" genes per individual. From this point of view, genes are "bad" if they cause sterility or in any way reduce the reproductive ability of the carrier. Any large, outbred population will have some such genes. Most are recessive and relatively rare. Homozygotes for such genes will be much rarer. (Recall that the frequency of a homozygote is the square of the frequency of that allele.)

Inbreeding depression is not an uncommon problem, though it is difficult to generalize about it. On the one hand, there are species that have been bred from very small founder stocks. All golden hamsters are descended from one pregnant female. Père David's deer is another example. On the other hand, relatively serious inbreeding depression has cropped up in the European bison (Slatis, 1960; Raczynski, 1975), the Przewalski horse (Volf, 1975), in the Hawaiian goose (Kear, 1975) and undoubtedly in many other zoo stocks. Only when lines have been "cleansed" by brother-sister mating for many generations can we be sure that no further loss of fitness due to inbreeding will develop.

Large animals may cost thousands of dollars a year to house and maintain, so anything that reduces the number necessary for the perpetuation of the colony and the space needed to house them, is usually considered desirable. Therefore, the best of all possible worlds for the breeder of captive animals is that one where brother-sister matings do not result in a significant loss of fitness; in other words, a stock can be maintained with just a single pair of animals.

This "ideal" situation* will rarely if ever be achieved with wild delphinids or any other large mammal or bird. But it would be desirable to be able to estimate ahead of time the minimum number that could be counted on to maintain the stock with certainty. To do this it is necessary to know the genetic load in the wild stock because once this is known one can predict the amount of inbreeding that could be tolerated. Any feasibility study for a breeding program would necessarily contain such analysis, assuming a method was available.

There is no method currently in use for assaying the genetic load of large animals. Dobzhansky (1963) and others have long been estimating genetic loads in wild populations of *Drosophila*. Mice (Falconer, 1971) and some domestic animals (e.g., Abplanalp, 1974) have also been studied. The problem is that the methods now in use require the breeding of large numbers of animals for several generations.

A new approach to this problem could be at hand, one that is very quick and relatively inexpensive. It is premature to announce this as a "breakthrough" because we are only now testing the idea in our laboratory. Nevertheless, it is so simple and logical that I don't mind going out on a limb.

The hypothesis is that the genetic loads of populations are correlated with their genetic variabilities as assayed by conventional electrophoretic surveys of enzyme and other protein. Since the publication of the seminal paper by Lewontin and Hubby (1966), estimates of genetic variability have been reported for hundreds of species (see reviews by Selander and Johnson (1973) and Soulé (1976)).

At least three lines of evidence lead to the conclusion that electrophoresis can give accurate assessments of genetic variation. The first is that the amount of genetic variation appears to be significantly related to population size (Soulé, 1976). The second is that among island populations of lizards there is always a statistically significant correlation between electrophoretic variation or heterozygosity and the area

* A situation ideal from the point of view of husbandry would be undesirable when considering the ultimate release of the stock back into nature, because survival in nature is probably maximized when there is a rich store of genetic variation.

of the continental island (Soule and Yang, 1974; Gorman *et al.*, 1975). Third, morphological variation in randomly chosen meristic and morphometric characters is significantly correlated with electrophoretic variation (Soulé *et al.*, 1973; Patton *et al.*, 1975). With regard to the latter, it would appear that both biochemical and morphological estimates of variation agree on ranking the variability in populations. Can this correlation be extrapolated to another category of variation, namely the genetic load? What are the assumptions that underlie such an inferential leap?

Most of the alleles that contribute to the genetic load of a population are recessives. The majority of the deleterious recessives arise by mutation (some are introduced by migration). By definition, therefore, these alleles are rare and increase in frequency only by genetic drift or if the heterozygote for them is overdominant. Assuming no heterosis and ignoring back mutation, the frequency of such an allele will fluctuate about the mutation-selection equilibrium. The larger these fluctuations, the more of these bad alleles will be lost; therefore relatively small populations will have less of a load than will large populations. Hence load, like heterozygosity, should be correlated with N . In general, then, this hypothesis is based on the assumptions that processes leading to a build-up of electrophoretic variation will also lead to a build-up of genetic load.

There is some circumstantial evidence that favors the proposed relationship between genetic variability and genetic load. Abplanalp and his colleagues of UC, Davis have been studying the effects of inbreeding on reproductive performance in several species of gallinaceous birds. They find (Abplanalp, 1974) that recently domesticated or wild species, such as Japanese quail and chukar partridge, have the highest load; next is the turkey; the least load is carried by domestic chickens. I argue that genetic variability should decrease in the same order. The wild species should have the most. The chicken should have the least because of repeated inbreeding and selection. I am now testing this by doing electrophoretic analyses on these species. In addition, I hope to obtain funds for research on inbreeding depression and genetic variation in jungle fowl and bob-white quail.

Needless to say, the "theory" on which this hypothesis is based deserves more consideration than it is given here. This will be done elsewhere. All I wish to point out here is that this hypothesis would permit us to predict that dolphins have very little genetic load, assuming that the very low levels of heterozygosity so far observed by Gary Sharpe of the U.S. Tuna Commission, NOAA, Southwest Fisheries Center, La Jolla (personal communication) are representative.

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